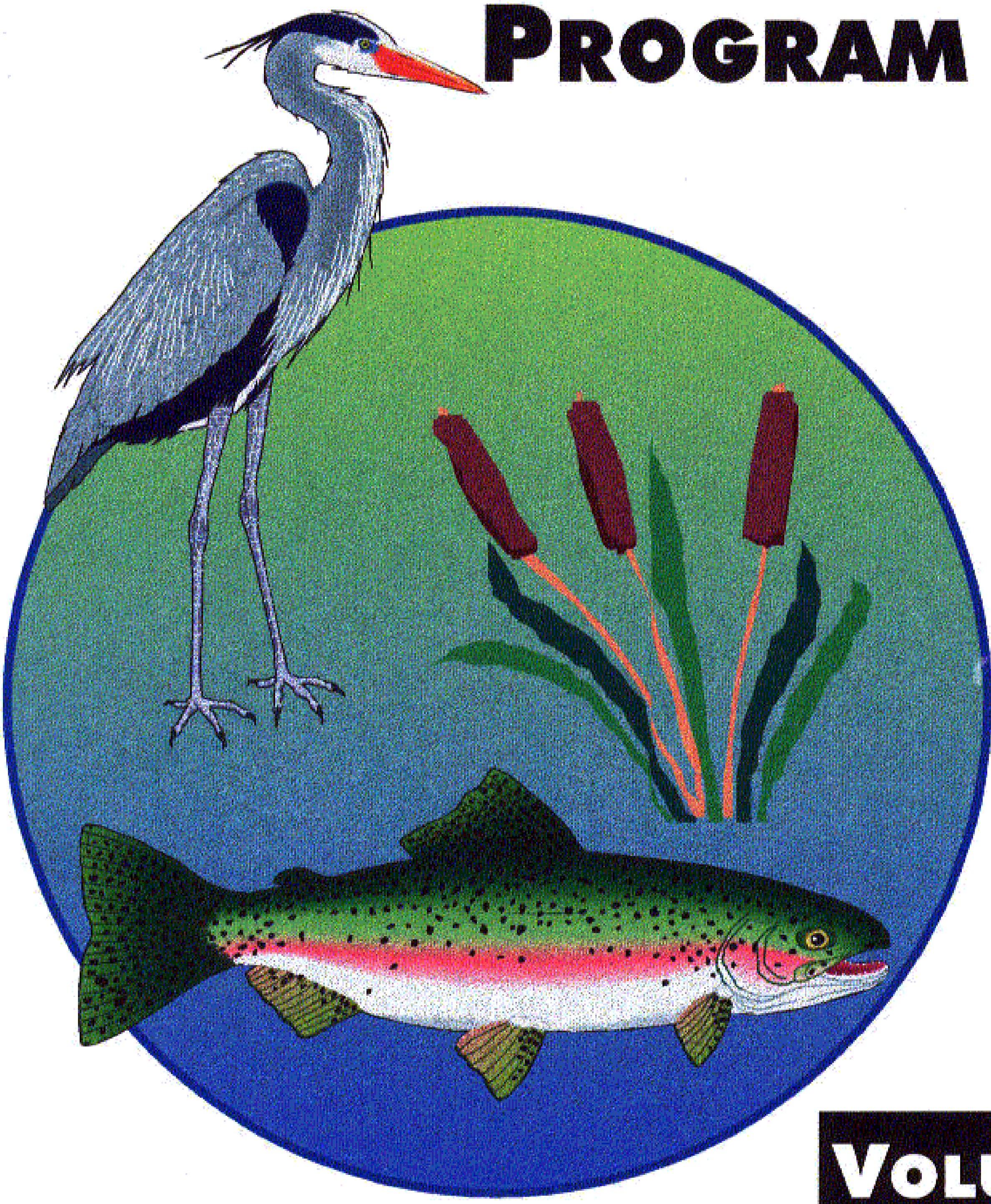
CALFED
BAY-DELTA
PROGRAM

# Ecosystem Restoration Program Plan
# Vol 2 - Ecological Management Zone Visions

Draft Programmatic EIS/EIR Technical Appendix

June 1999

# Ecosystem Restoration Program Plan



## Volume II

## Ecological Management Zone Visions

CALFED
BAY-DELTA
PROGRAM

June 1999

# CALFED BAY-DELTA PROGRAM
# ECOSYSTEM RESTORATION PROGRAM PLAN
# VOLUME II: ECOLOGICAL MANAGEMENT ZONE VISIONS

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# ENVIRONMENTAL DOCUMENTATION

The CALFED Bay-Delta Program (Program) is currently in what is referred to as Phase II, in which the CALFED agencies are developing a Preferred Program Alternative that will be subject to a comprehensive programmatic environmental review. This report describes both the long-term programmatic actions that are assessed in the June 1999 Draft Programmatic EIS/EIR, as well as certain more specific actions that may be carried out during implementation of the Program. The programmatic actions in a long-term program of this scope necessarily are described generally and without detailed site-specific information. More detailed information will be analyzed as the Program is refined in its next phase.

Implementation of Phase III is expected to begin in 2000, after the Programmatic EIS/EIR is finalized and adopted. Because of the size and complexity of the alternatives, the Program likely will be implemented over a period of 20-30 years. Program actions will be refined as implementation proceeds, initially focusing on the first 7 years (Stage I). Subsequent site-specific proposals that involve potentially significant environmental impacts will require site-specific environmental review that tiers off the Programmatic EIS/EIR. Some actions, such as recreation of shallow water habitats in the Delta and Suisun Marsh, also will be subject to permit approval from regulatory agencies.

# ◆ CALFED BAY-DELTA PROGRAM ECOSYSTEM RESTORATION PROGRAM PLAN

## OVERVIEW

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. The Program addresses problems in four resource areas: ecosystem quality, water quality, levee system integrity, and water supply reliability. Programs to address problems in the four resource areas will be designed and integrated to fulfill the CALFED mission.

Ecosystem goals presented in the ***Strategic Plan for Ecosystem Restoration*** will guide the Ecosystem Restoration Program (ERP) during its implementation phase. Strategic Goals include the following:

1. Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

2. Rehabilitate natural processes in the Bay-Delta system to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities, in ways that favor native members of those communities.

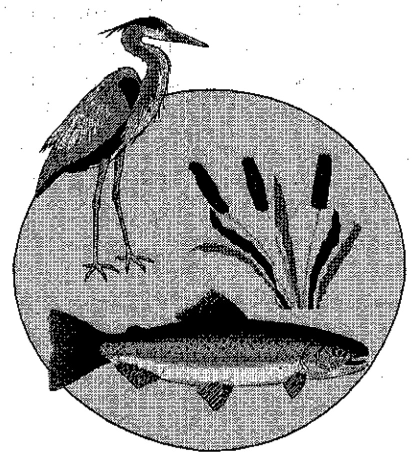
3. Maintain and enhance populations of selected species for sustainable commercial and recreational harvest, consistent with goals 1 and 2.

4. Protect or restore functional habitat types throughout the watershed for public values, such as recreation, scientific research, and aesthetics.

5. Prevent establishment of additional non-native species and reduce the negative biological and economic impacts of established non-native species.

6. Improve and maintain water and sediment quality to eliminate, to the extent possible, toxic impacts to organisms in the system, including humans.

The ERP addresses these goals by restoration of ecological processes associated with streamflow, stream channels, watersheds, and floodplains. These processes create and maintain habitats essential to the life history of species dependent on the Delta. In addition, the Program aims to reduce the effects of stressors that inhibit ecological processes, habitats, and species.



## ORGANIZATION OF THE PLAN

The ERP is comprised of a Strategic Plan and the two volume restoration plan:

- Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed

- Volume II: Ecological Management Zone Visions.

**STRATEGIC PLAN FOR ECOSYSTEM RESTORATION** provides the ERP approach to adaptive management and contains the proposed plans for indicators of ecological health, a monitoring program to acquire and evaluate the data needed regarding indicators, a program of focused research to acquire additional data needed to evaluate program alternatives and options, and the approach to staging and implementation of the ERP over time.

**VOLUME I: ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED** presents the visions for ecological processes and functions, fish and wildlife habitats, species, and stressors that impair the health of the processes, habitats, and species (Figure 1). The visions presented in Volume I are the foundation

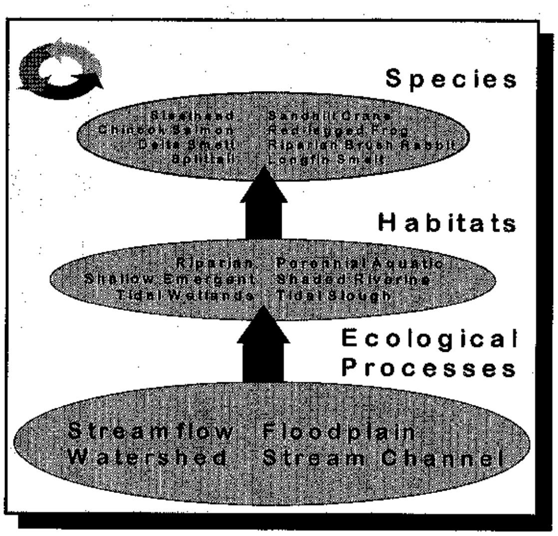



Figure 1. Relationship of ecological, processes, habitats, and species in the Ecosystem Restoration Program Plan.

of the ERP and display how the many ecosystem elements relate to one another and establish a basis for actions which are presented in Volume II.

**VOLUME II: ECOLOGICAL MANAGEMENT ZONE VISIONS** presents the visions for the 14 ecological management zones and their respective ecological management units. Each individual ecological management zone vision contains a brief description of the management zone and units, important ecological functions associated with the zone, important habitats, species which use the habitats, and stressors which impair the functioning or utilization of the processes and habitats. Volume II also contains strategic objectives, targets, and programmatic actions which describe the ERP approach to improving the ecological health of the zone and its contribution to the health of the Delta. Rationales are also contained in Volume II which clarify, justify, or support the targets and programmatic actions.

## INTRODUCTION TO VOLUME II

Volume II, Ecological Management Zone Visions, integrates the landscape ecological concepts for processes, habitats, species, and stressors presented in Volume I: Visions for Ecosystem Elements. Volume II presents this information in population targets and actions for species and 14 visions for the Ecological Management Zones which comprise the ERPP Study Area (Table 1).

Each Ecological Management Zone (Zone) is further divided into component Ecological Management Units (Unit). For example, the East San Joaquin Zone is divided into three Units: Stanislaus River, Tuolumne River, and Merced River. The vision for each Ecological Management Zone provides introductory information, Zone and Unit descriptions which identify the status of ecological processes, habitats, and species, and describes how stressors adversely affect those ecosystem elements.

**Table 1. Ecological Management Zones and Ecological Management Units within the ERPP Study Area.**

| Ecological Management Zone | Ecological Management Unit | |
|---|---|---|
| Sacramento-San Joaquin Delta | North Delta<br>South Delta | East Delta<br>Central and West Delta |
| Suisun Marsh/North San Francisco Bay | Suisun Bay and Marsh<br>Sonoma Creek<br>San Pablo Bay | Napa River<br>Petaluma River |
| Sacramento River | Keswick to Red Bluff<br>Chico Landing to Colusa<br>Verona to Sacramento | Red Bluff to Chico Landing<br>Colusa to Verona |
| North Sacramento Valley | Clear Creek<br>Bear Creek | Cow Creek<br>Battle Creek |
| Cottonwood Creek | Upper Cottonwood Creek | Lower Cottonwood Creek |
| Colusa Basin | Stony Creek<br>Thomes Creek | Elder Creek<br>Colusa Basin |
| Butte Basin | Paynes Creek<br>Mill Creek<br>Big Chico Creek<br>Butte Sink | Antelope Creek<br>Deer Creek<br>Butte Creek |
| Feather River/Sutter Basin | Feather River<br>Bear River<br>Sutter Bypass | Yuba River<br>Honcut Creek |
| American River Basin | American Basin | Lower American River |
| Yolo Basin | Cache Creek<br>Solano | Putah Creek<br>Willow Slough |
| Eastside Delta Tributaries | Cosumnes River<br>Calaveras River | Mokelumne River |
| San Joaquin River | Vernalis to Merced<br>Mendota Pool to Gravelly Ford | Merced to Mendota Pool<br>Gravelly Ford to Friant |
| East San Joaquin | Stanislaus River<br>Merced River | Tuolumne River |
| West San Joaquin | | |

Visions follow the introductory material for each Zone which presents the relevant ecological processes, habitats, species and stressors within the Zone and Unit. The visions are followed by sections on how restoration efforts in the Zone integrate with other programs and how the Zone is linked to other Zones. The final section of each vision provides implementation objectives, targets, and programmatic restoration actions.

## PERSPECTIVE

The ecological hub of the Central Valley is the Sacramento-San Joaquin Delta and Bay. The ERP signals a fundamental shift in the way ecological resources of the Central Valley are managed. For many decades, government entities, non-profit organizations, and the private sector have engaged in managing, protecting, regulating, and in some cases breeding fish and wildlife species of the Bay and Delta - yet many populations have not recovered sufficiently and remain in decline. In spite of constant human intervention to repopulate fish and wildlife that have commercial, recreational, and biological importance to society (e.g., hatchery programs and expensive re-engineered water diversions), populations have not been sustained at stable, healthy levels that support historic utilization of those resources.

Historic efforts at individual species regulation and management will be replaced by an integrated systems approach that aims to reverse the fundamental causes of decline in fish and wildlife populations. A systems approach will recognize the natural forces that created historic habitats and use these forces to help regenerate habitats. The Bay-Delta ecosystem is not simply a list of species. Rather, it is a complex living system sustained by innumerable interactions that are physical, climatic, chemical, and biological in nature, both within and outside of the geographic boundaries of the Delta.

**The central theme of the ERPP is the recognition that truly durable *and resilient populations of all* fish and wildlife inhabiting the Bay and Delta require, above all else, the rehabilitation of ecological processes throughout the Central Valley river and estuary systems and watersheds.**

The ERP is fundamentally different from many past efforts in another way as well. It is not designed as mitigation for projects to improve water supply reliability or to bolster the integrity of Delta levees; improving ecological processes and increasing the amount and quality of habitat are co-equal with other program goals related to water supply reliability, water quality, and levee system integrity. Solving serious and long-standing problems in each of these resource areas will require an ambitious, integrated, long-term program. We do not know the balance needed between restoration efforts in the Delta and Bay and restoration efforts upstream. However, aquatic species cannot be the sole driving force for ecosystem restoration. Ecosystem restoration must involve the integration of the needs of terrestrial and aquatic species and plant communities.

The ERP, like all components of Bay-Delta solution alternatives, is being developed and evaluated at a programmatic level. The complex and comprehensive nature of a Bay-Delta solution means that it will necessarily be composed of many different programs, projects, and actions that will be implemented over time. During the current phase of the Program, solution alternatives have been evaluated as sets of programs and projects and broad benefits and impacts have been identified. In the implementation phase of the Program, more focused analysis, environmental documentation, and implementation of specific programs and actions will occur.

The CALFED goal for ecosystem quality will be achieved by further developing and adhering to the *Strategic Plan for Ecosystem Restoration*. A major effort toward reaching target levels will be emphasized during the first 7 years of the implementation program. Special effort will be directed to actions that can be implemented to restore ecological processes. The restoration of these processes is intended to restore and maintain habitats, and to provide for the needs of the species dependent on a healthy Bay-Delta system. For example, restoring stream channels contributes to sediments, nutrients, and a variety of habitats. The strategy recognizes that not all processes can or should be completely restored and that intervention, manipulation, and management will be required. For example, streambed gravel may have to be introduced, habitats may have to be constructed, and vegetation planted. Still, an important part of the approach is to recommend measures that in the long-term will limit the need for continued human intervention.

Implementation of the ERP is further guided by the recognition that all landscape units and physical and biological components of the ecosystem are interdependent and dynamic. Interdependence means that actions and stressors in one part of the system can and do affect populations and conditions that may be separated by hundreds of miles (e.g., in watersheds and spawning tributaries), or affect the food web in ways that may not be felt for several years.

Natural systems are dynamic; i.e., they are characterized by response to cycles of change and episodic catastrophes that are driven by natural or human factors. Most habitats undergo expansions and contractions, or shifts in space and time. The dynamic nature of healthy habitats is the cause of much biological diversity, and complex habitats tend to make species populations more resilient to change. If the mosaic of habitats distributed across a broad landscape is complex, and if large areas of habitat are connected by smaller patches and corridors such as those associated with riparian systems, then healthy areas of the ecosystem can be relied upon to sustain species during temporary setbacks in other areas.

## GEOGRAPHIC SCOPE

The geographic (spatial) scope of the ERP is defined by the interdependence and linkage of the ecological zones which encompass the Central Valley. These ecological zones include the upland river-riparian systems, alluvial river-riparian systems, the Delta, and Greater San Francisco Bay (Note: These ecological zones are more fully described in the Volume I section on Key Ecological Attributes of the San Francisco-Bay Delta Watershed.) The geographic scope defines the locations where actions might be implemented to maintain, protect, restore, or enhance important ecological processes, habitats, and species. Some rivers or watersheds have ecological attributes which are valued higher than the attributes of others areas. These ecological values include the condition of important ecological processes and how well they support a diversity of habitats. The values also include the fish, wildlife, and plants which occupy or utilize the habitats within these local areas.

CALFED is developing a Multi-Species Conservation Strategy to serve as the platform for compliance with the Federal Endangered Species Act (ESA), the California Endangered Species Act (CESA), and the State's Natural Community Conservation Planning Act (NCCPA). The Conservation Strategy has identified a subset of species which are federally and State listed, proposed, or candidate species, other species identified by CALFED that may be affected by and for which the CALFED Program and the ERP have responsibility related to (1) recover the species, (2) contributing to their recovery, or (3) maintaining existing populations. The "recover species" depend on habitat conditions in Suisun Bay, the Delta, Sacramento River, San Joaquin River, and many of their tributary streams. For these reasons, the primary geographic focus of the ERP is the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. In addition, streams such as Mill Creek, Deer Creek, Cottonwood Creek, and Cosumnes River, for example, are emphasized due to their free-flowing status and relative high quality of habitats and ecological processes.

Secondarily, the ERP addresses, at a broader, programmatic level, Central and South San Francisco Bay and their local watersheds (Note: The primary geographic focus area for the ERP can be divided into 14 management zones, each characterized by a predominant physical habitat type and species assemblage.) These 14 ecological management zones constitute the geographic areas in which the majority of restoration actions will occur. The upper watersheds surrounding the primary focus area are important and addressed through general actions that focus on watershed processes and watershed planning, management and restoration. The CALFED Coordinated Watershed Management Program addresses the coordination of planning and restoration actions in the upper watershed regions.

## IMPLEMENTATION STRATEGY

A large and diverse ecosystem like the Bay-Delta is extremely complex. There are many processes and relationships at work in the ecosystem that are not fully understood. Thus, there are many difficulties and uncertainties associated with a program to improve ecosystem health. In some cases, problems are well understood and the steps to improvement are clear. In other cases, there is some understanding of the reasons for decline but this understanding is not sufficient to warrant full-scale implementation of remedial measures. In still other cases, additional research is needed before solutions can be identified with certainty.

The difficulties and uncertainties of ecosystem restoration call for an implementation strategy that is flexible and can accommodate and respond to new information. The foundation of the ERP implementation strategy is adaptive management. Adaptive management is a process of testing alternative ways of meeting objectives, and adapting future management actions according to what is learned. Adaptive management relies upon the identification of indicators of ecosystem health, comprehensive monitoring of indicators to measure improvement over time, focused research, and phasing of actions.

**INDICATORS** are features or attributes of the ecosystem that are expected to change over time in response to implementation of the ERP. Indicators are selected to provide measurable evaluations of important ecological processes, habitats, and species whose status individually and cumulatively provide an assessment of ecological health. Indicators of ecosystem health are the gauges we will use to measure progress toward the goal. Some indicators are very broad in scale while others are very specific. For example, a very broad or landscape level indicator of ecosystem health might be a comparison of the total area of riparian forest to historic coverage or an evaluation of the average distance between patches of such forest with closer patches indicating better health than more distant patches. A more specific indicator might be the concentration of toxic substances in the flesh of adult striped bass.

**COMPREHENSIVE MONITORING** is the process of measuring the abundance, distribution, change or status of indicators. For example, contaminant concentrations in fish tissues can be measured at various locations and times in the system to determine if contaminant levels are changing. This will allow progress to be measured, allow actions to be modified if necessary, and provide assurances that the restoration objectives are being achieved. (Note: A Comprehensive Monitoring, Assessment, and Research Program is being developed. A description of that program is presented later in this section.)

**DIRECTED RESEARCH** will help answer questions about the system and its components and increase the certainty surrounding the relationships of ecological processes, habitats, and species. For example, the relationships among streamflow, storm events, flow-related shaping of river channels to modify habitat, and the physical and chemical signals that flow provides for aquatic species all need to be better understood for effective management of the system. (Note: A Comprehensive Monitoring, Assessment, and Research Program is being developed. A description of that program is presented later in this section.)

**STAGED IMPLEMENTATION** is the logical sequence of implementing restoration actions to achieve CALFED goals as effectively as possible. Phasing will consider all targets and programmatic actions and will be used to prioritize actions. For example, actions directed at recovering endangered species and which are consistent with the long-term restoration program and contribute to ecological resilience have a high priority.

Stage I implementation is defined as the first 7 year phase of the program and will include restoration of ecological processes and habitats that are most important for endangered species recovery, reduction of stressors that affect threatened and endangered species, and other actions that may reduce conflicts between beneficial uses in the system. Later implementation phases will be shaped through adaptive management by the results of restoration actions in the first 7 years of the program.

The ERP will be refined and implemented according to the steps listed below.

1. **REFINE THE ERP** based on broad public participation, and using the best scientific knowledge currently available in the short term.

2. **CREATE AN ECOSYSTEM SCIENCE PROGRAM** to provide ongoing scientific evaluation of the ERP. The Science Program will be a collaborative effort among local and national, independent stakeholder and agency scientists and technical experts convened to address outstanding scientific issues and review the ERP.

3. **PREPARE CONCEPTUAL MODELS** to describe the Bay-Delta ecosystem and the proposed actions of the ERP. Restoration or rehabilitation programs for complex ecosystems must be based on clear concepts about how the system is believed to function, how it has been altered or degraded, and how various actions might improve conditions in the system. Conceptual models can provide a basis for quantitative modeling or identify critical information needs for research or monitoring. In ecosystem restoration, they can be used to link human activities or management actions to outcomes important to society. In adaptive management, the most important uses of conceptual models are for: linking human activities to valued outcomes, highlighting key uncertainties where research or adaptive probing might be necessary, and identifying monitoring needs.

4. **DEVELOP TESTABLE HYPOTHESES** for proposed ERP actions. The hypotheses underlying the ERP will be tested through experiments using the conceptual models and on-the-ground research. The results from these experiments will feed back into the adaptive management process and will support proposed actions, suggest revisions to actions, and identify needs for further research.

5. **CONDUCT IMMEDIATE DIRECTED RESEARCH** to improve understanding of the ecosystem and the causes of problems identified in the conceptual models and testable hypotheses. Use results from short-term studies to adjust the way that objectives are achieved, making refinements to the final ERP targets, actions, and implementation schedule.

6. **DEVELOP AND BEGIN A STAGED IMPLEMENTATION PROGRAM** that entails:

- short-term implementation of ecosystem restoration demonstration projects (e.g., through Restoration Coordination and related programs), including stressor reduction measures, to help threatened populations begin recovering and to test the viability and effectiveness of targets and actions,

- coordinated monitoring, evaluation, and reporting of the results of recovery efforts, and the status of ecological indicators in the Bay-Delta and other zones, and

- adaptive management of each successive phase of ERP implementation, including pragmatic adjustments to ecosystem targets, funding priorities, and restoration techniques to ensure that public and private resources are well spent and complement other related efforts.

During refinement and implementation of the ERP, public accountability and program effectiveness will be assured through continuing public involvement as well as environmental impact analysis and documentation.

## COMPREHENSIVE MONITORING, ASSESSMENT, AND RESEARCH PROGRAM

Many institutions, both within and outside of the CALFED partnership, are involved in monitoring and applied research that can contribute to the design and assessment of environmental rehabilitation programs. The scope, coverage, and coordination of existing monitoring and applied research, however, are admittedly fragmentary. When viewed together, these programs do not provide a coherent, overall picture of what is being monitored, how the environment is changing over large spatial scales, or a clear sense of how the monitoring data might be used by resource managers and decision makers. The ability to provide coordinated and complete monitoring coverage is especially difficult because of the complex system structure, and the complexities of the associated physical and ecological processes. These programs, however, provide information essential to our understanding and management of the system. These existing programs will figure prominently in the development of a Comprehensive Monitoring, Assessment and Research Program (CMARP) (CMARP Steering Committee 1998).

Monitoring, assessment, and research are important steps in an iterative process to understand and manage a natural resource system. Monitoring involves measuring and sampling physical, chemical, and biological attributes of the resources and can include social and economic attributes of associated human activities. Assessment involves developing correlations among monitored data, for example correlations between the abundance of a fish species and a factor such as river flow that might affect abundance. Research involves analysis or experiments to establish mechanisms that explain observed correlations, such as documenting fish distributions and mortalities for different flows. The information generated from monitoring, assessment, and research provides resource managers with understanding needed to design actions and to detect responses to their actions.

CALFED needs a monitoring and research program for at least four reasons. First, CALFED needs monitoring data and information to implement the preferred program alternative and to carry out its related programs, and this need is increased by CALFED's adoption of an adaptive management strategy. Second, CALFED needs to satisfy the Congressional mandate for indicators and performance measures with which to judge the success of restoration efforts. Third, CALFED needs data and information with which to assure stakeholders that the actions being taken are having desired results. Finally, CALFED needs to reduce the scientific uncertainty regarding the management and protection of valued natural resources.

Thus, the purpose of CMARP is to provide those new facts and scientific interpretations necessary for CALFED to implement fully its preferred program alternative and related programs and for the public and government to evaluate the success of CALFED actions.

## TERMS USED IN THE ERPP

The following terms are used in the ERP:

**ECOSYSTEM-BASED MANAGEMENT:** Ecosystem-based management is a resource management concept of achieving species management objectives by sustaining and enhancing the fundamental ecological structures and processes that contribute to the well being of the species. A basic tenant of CALFED's implementation of ecosystem-based management is, to the extent feasible, to restore or rehabilitate the natural processes that create and maintain the important elements of ecosystem structure. Ecosystem-based management differs fundamentally from the more traditional approach of species-based management, which seeks to manipulate specific environmental factors (e.g., direct removal of predators from the environment to reduce predation levels on the target species) thought to be limiting target species populations at levels below management objectives.

**ECOSYSTEM ELEMENT:** An ecosystem element is a basic component or function which, when combined with other ecosystem elements, make up an ecosystem. An ecosystem element can be categorized as a process, habitat, species, species community or stressor.

**ECOSYSTEM REHABILITATION:** Within CALFED's concept of ecosystem restoration, the ERP will largely focus on ecosystem rehabilitation. In the context of CALFED, ecosystem rehabilitation is defined as the process by which resource managers reestablish or refurbish key elements of ecological structure and function within the Bay-Delta ecosystem to a level necessary to achieve ERP goals and objectives.

**ECOSYSTEM RESTORATION:** Ecosystem restoration is a term sometimes used to imply the process of recreating the structural and functional configurations of an ecosystem to that present at some agreed to time in the past. Because the structure and function of many elements of the Bay-Delta ecosystem have been severely disrupted and cannot be feasiblely restored to a specified historic condition, within the context of CALFED, ecosystem restoration is more realistically defined as the process by which resource managers ensure that the capacity of the ecosystem to provide ecological outcomes valued by society is maintained, enhanced, or restored.

**ECOLOGICAL PROCESS:** Ecological processes act directly, indirectly, or in combination, to shape and form the ecosystem. These include streamflow, watershed, stream channel, and floodplain processes. Watershed processes are closely linked to streamflow and include fire and erosion. Stream channel processes include stream meander, gravel recruitment and transport, water temperature, and hydraulic conditions. Floodplain processes include overbank flooding and sediment retention and deposition.

**HABITATS:** Habitats are areas that provide specific conditions necessary to support plant, fish, and wildlife communities. Some important habitats include gravel bars and riffles for salmon spawning beds, winter seasonal floodplains that support juvenile fish and waterbirds, and shallow near-shore aquatic habitat shaded by overhanging tule marsh and riparian forest.

**LONG- AND SHORT-TERM OBJECTIVES:** Objectives can be both short-term and long-term. Short-term objectives should be clearly feasible, relatively easy to measure, and achievable in reasonable length of time (usually <25 years). The time period is not the same as Stage I of the CALFED process. Long-term objectives may be more difficult to determine and require additional resources and knowledge to achieve.

**PROGRAMMATIC ACTION:** A programmatic action represents a physical, operational, legal, institutional change or alternative means to achieve a target. The number of actions and their level of implementation is subject to adjustment by adaptive management. For example, the number of diversions screened may be adjusted up or down depending on the overall response of fish populations to screening and other restoration actions.

An example of a programmatic action is to develop a cooperative program to acquire and restore 1,500 acres of shallow-water habitat in the Suisun Bay and Marsh Ecological Management Unit.

**STRATEGIC OBJECTIVES:** Strategic objectives are a more detailed delineation of the Strategic Goal components and provide a framework to develop and organize targets and programmatic actions. A strategic objective is the most specific and detailed description of what the ERP strives to maintain or achieve for an ecosystem element. The objectives are stated primarily in terms of management actions designed to have a favorable impact on the Bay-Delta system, however, some are also stated in terms of studies that will teach us how the ecosystem behaves so that principles of adaptive management can be better employed.

**SPECIES AND SPECIES GROUPS:** Certain species or groups of species are given particular attention in the ERP. This focus is based on three criteria that might be met by a species (including fish, wildlife, and plants): 1) is it a formally listed threatened or endangered species (e.g., winter-run chinook salmon, delta smelt), or is it a species proposed for listing; 2) it is economically important, supporting a sport or commercial fishery (e.g., striped bass, signal crayfish); 3) is it a native species or species community that is presently not listed by which could be if population abundance or distribution declines, or 4) it is an important prey species (e.g., Pacific herring).

**STAGE 1 EXPECTATIONS:** Stage 1 expectations are meant to be measures of the progress towards meeting short-term objectives in the first 7 years of implementation program. These expectations have two basic components: improvements in information to allow better management of the ecosystem and improvements in physical and biological properties of the Bay-Delta ecosystem and watershed.

**STRATEGIC GOAL:** Strategic goals are the broad statements that define the scope and purposes of the ERP. Strategic goals provide guidance in the development and evaluation of proposed restoration actions.

**STRESSORS:** Stressors are natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Environmental stressors include water diversions, water contaminants, levee confinement, stream channelization and bank armoring, mining and dredging in streams and estuaries, excessive harvest of fish and wildlife, introduced predator and competitor species, and invasive plants in aquatic and riparian zones. Some major stressors affecting the ecosystem are permanent features on the landscape, such as large dams and reservoirs that block transport of the natural supply of woody debris and sediment in rivers or alter unimpaired flows.

**TARGET:** A target is a qualitative or quantitative statement of an implementation objective. Targets are something to strive for but may change over the life of the program with new information and progress, or may vary according to the configuration of storage and conveyance in all alternatives. Targets may include a range of values or a narrative description of the proposed future value of an ecosystem element. Targets are to be set based upon realistic expectations, must be balanced against other resource needs and must be reasonable, affordable, cost effective, and practicably achievable.

The intent of the ERP is to achieve ecosystem health; targets are flexible tools to guide the effort. The level of implementation for each target will be determined or adjusted through adaptive management. Targets are categorized according to the three levels of certainty described above: (1) targets that have sufficient certainty of success to justify full implementation in accordance with program priorities and staged implementation; (2) targets which will be implemented in stages with the appropriate monitoring and evaluation to judge benefits and successes; and (3) targets for which additional research, demonstration and evaluations are needed to determine feasibility or ecosystem response.

Examples of targets for tidal perennial aquatic habitat are to restore 1,500 acres of shallow-water habitat in the Suisun Marsh/North San Francisco Bay Ecological Management Zone and restore 2,000 acres of shallow-water habitat in the South Delta Ecological Management Unit.

**VISION:** A vision is what the ERP will accomplish with the stated objectives, targets, and programmatic actions for an ecological process, habitat, species or species group, stressor, or geographical unit. The vision statements included in the ERP provide technical background to increase understanding of the ecosystem and its elements. Two types of vision statements are included in the ERP: visions for ecosystem elements and visions for ecological zone. A resource vision addresses an individual ecological processes, habitat, species or species group, or stressor, while an ecological zone vision addresses the integration of ecological processes, habitats, species, and stressors within a clearly delineated geographical area. Cumulatively, the visions also provide detailed descriptions of the ecosystem and its elements as they will look and function after restoration is accomplished.

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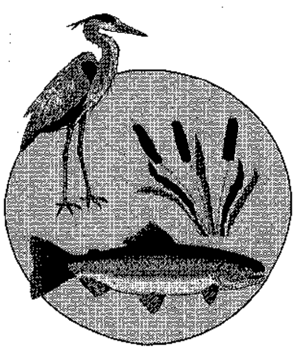
# ◆ POPULATION TARGETS AND PROGRAMMATIC ACTIONS FOR SPECIES AND SPECIES GROUPS

## INTRODUCTION

This section presents the approach for describing population targets and programmatic actions for species and species groups. Many of these population targets are linked to formal recovery plans for State- or federally listed threatened or endangered species and, therefore, constitute an exceedingly important component of the overall ecosystem restoration program.



Broad species and species group population targets are presented here, prior to our discussion of individual ecological management zones, to avoid redundancy. Where necessary, we provide additional targets and actions within the ecological management zone descriptions if they differ or are in addition to the initial presentation of species population targets and programmatic actions.

Little recent information regarding abundance, distribution, or life history requirements are available for some species. This limits our ability to develop species targets and programmatic actions. Instead, some targets are presented as information needs, such as a target for lamprey would be to conduct distributional and abundance surveys to enable the development of lamprey targets and programmatic actions. These information-directed targets are linked to the Comprehensive Monitoring, Assessment, and Research Program (CMARP) which is developing the CALFED monitoring and research program.

Consistent with the Strategic Plan, this section is divided into five segments that correspond with the classification system used for Strategic Objectives. Four of the segments fall under Strategic Goal 1 (at-risk species) and the remaining segment is linked to Goals 3 (harvested species).

### STRATEGIC GOALS

1. Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

3. Maintain and enhance populations of selected species for sustainable commercial and recreational harvest, consistent with goals 1 and 2.

The divisions follow:

- **HIGH PRIORITY AT-RISK SPECIES** (Priority Group I): These are at-risk native species dependent on the Bay-Delta system, most of them listed under the Endangered Species Act (ESA) or proposed for listing, whose management for restoration implies substantial manipulations of the ecosystem (e.g., requiring large amounts of fresh water at certain times of the year).

- **At-risk Native Species** (Priority Group II): These are at-risk native species dependent on the Bay-Delta system whose restoration is not likely to require large-scale manipulations of ecosystem processes because they have limited habitat requirements in the estuary and watershed (e.g., brackish water plants).

- **At-risk Upstream Native Species** (Priority Group III): These are at-risk species that primarily live upstream of the estuary or in local watersheds of San Francisco Bay.

- **Declining Native Species** (Priority Group IV): These are native species in the estuary and watershed not yet at risk of extinction that have the potential to achieve that status if steps are not taken to reverse their declines or keep populations at present levels. Their rehabilitation either does not depend on conditions in the Bay-Delta system or depends on unknown factors.

- **Harvested Species:** These are species that support recreational and commercial harvest not already covered by the previous classes.

## Linkage to Conservation Strategy

The Multi-species Conservation Strategy (MSCS) addresses all federally and State listed, proposed, and candidate species that may be affected by the CALFED Program; other species identified by CALFED that may be affected by the Program and for which adequate information is available also are addressed in the MSCS. The term "evaluated species" is used to refer to all of the species addressed by the Conservation Strategy. Please refer to the MSCS appendix (bound separately) for more information and for a complete list of evaluated species.

**Recovery "R":** For those species designated "R" the CALFED Program has established a goal to recover the species within the CALFED ERP Ecological Management Zones. A goal of "Recovery" was generally assigned to those species whose range is entirely or nearly entirely within the area affected by the CALFED Program and for which CALFED could reasonably be expected to undertake all or most of the actions necessary to recovery the species. The term "recover" generally means the decline of a species is arrested or reversed, threats to the species are neutralized, and thus, the species' long-term survival in nature is assured. In the case of most species listed under the Federal ESA, recovery is equivalent, at a minimum, to the requirements of delisting. For certain species, such as anadromous fish, with threats outside the geographic scope or purview of the CALFED Program, CALFED may not be capable of completely recovering the species, but will implement all necessary recovery actions within the ERP Ecological Management Zones. For other species, CALFED may choose a goal that aims to achieve more than would be required for delisting (e.g., restoration of a species and/or its habitat to a level beyond delisting requirements). The effort required to achieve the goal of "Recovery" may be highly variable between species. In sum, a goal of "Recovery" implies that CALFED will undertake all actions within the ERP Ecological Management Zones and program scope necessary to recover the species.

**Contribute to Recovery ("r"):** For those species designated "r," the CALFED Program will make specific contributions toward the recovery of the species. The goal "Contribute to Recovery" was generally assigned to those species for which CALFED Program actions affect only a limited portion of the species range and/or CALFED Program actions have limited effects on the species. In the case of a species with a recovery plan, this may mean implementing some of the measures identified in the plan. For species without a recovery plan, this would mean implementing specific measures that would benefit the species. In sum, a goal of contributing to a species' recovery implies that CALFED will undertake some of the actions within its geographic scope necessary to recovery the species.

**MAINTAIN ("M")**: For those species designated "m," the CALFED Program will undertake actions to maintain the species (this category is less rigorous than Contribute to Recovery). The goal "Maintain" was generally assigned to species expected to be minimally affected by CALFED actions. For this category, CALFED will ensure that any adverse effects to the species are addressed commensurate with the level of effect on the species; thus, actions may not actually contribute to the recovery of the species, but would be expected, at a minimum, to not contribute to the need to list an unlisted species or degrade the status of an already listed species. CALFED will also maximize beneficial effects on these species to the extent practicable.

# SPECIES POPULATION TARGETS AND PROGRAMMATIC ACTIONS

Targets developed for the species and species groups can be classified by their reliability in contributing to attainment of the Strategic Objectives. The target classification system used in the following section is as follows:

| Class | Description |
|---|---|
| ◆ | Target for which additional research, demonstration, and evaluation is needed to determine feasibility or ecosystem response. |
| ◆◆ | Target which will be implemented in stages with the appropriate monitoring to judge benefit and success. |
| ◆◆◆ | Target that has sufficient certainty of success to justify full implementation in accordance with adaptive management, program priority setting, and phased implementation. |

***Strategic Plan Priority Group I.*** At-risk native species dependent on the Bay-Delta system, most of them listed under the Endangered Species Act (ESA) or proposed for listing, whose management for restoration implies substantial manipulations of the ecosystem (e.g., requiring large amounts of fresh water at certain times of year).

## DELTA SMELT (R)[1]

**POPULATION TARGET**: Meet Delta Native Fishes Recovery Plan goals which include recovery goals tied to the fall midwater trawl survey and distribution of catch in various trawl survey zones (◆◆).

**PROGRAMMATIC ACTION**: Restoring delta smelt will come indirectly from increasing March to May Delta inflow and outflow; Delta channel hydraulics, the Delta aquatic foodweb, and aquatic wetland and riparian habitats; and reducing stressors including effects of water diversions and contaminants.

***RATIONALE:*** *The recovery objective for delta smelt is to remove delta smelt from the Federal list of threatened species through restoration of it abundance and distribution. Recovery of delta smelt should not be at the expense of other native fishes. The basic strategy for recovery is to manage the estuary in such a way that it is a better habitat for native fish in general and delta smelt in particular. Improved habitat will allow delta smelt to be widely distributed throughout the Delta and Suisun Bay, recognizing that areas of abundance change with season.*

*Recovery of delta smelt will consist of two phases, restoration and delisting. Separate restoration*

[1]. Note: Letter in parentheses refers to Conservation Strategy goal for the species. (e.g., "R" is recovery of the species, "r" is contribute to recovery, "m" is maintain species, and "nc" is not covered.

*and delisting periods were selected because it is possible that restoration criteria could be met quicky in the absence of consecutive extreme outflow years (i.e., extremely wet or dry years). However, without the population being tested by extreme outflows there is no assurance of long-term survival for the species.*

*Thus restoration is defined as a return of the population to pre-decline levels, but delisting is not recommended until the population has been tested by extreme outflows. Delta smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period. This period was chosen because it includes the earliest continuous data on delta smelt abundances and was a period in which populations stayed reasonably high in most years. The species will be considered recovered and qualify for delisting when it experiences a five-year period that includes two sequential years of extreme outflows, one of which must be dry or critically dry. Delta smelt will be considered for delisting when the species meets recovery criteria under stressor conditions comparable to those that led to listing and mechanisms are in place that insure the species' continued existence.*

*Restoration of delta smelt should be assessed when the species satisfies distributional and abundance criteria. Distributional criteria include: (1) catches of delta smelt in all zones 2 of 5 consecutive years, (2) in at least two zones in 1 of the remaining 3 years, and (3) in at least one zone for the remaining 2 years. Abundance criteria are: delta smelt numbers of total catch must equal or exceed 239 for 2 out of 5 years and not fall below 84 for more that two years in a row. Distributional and abundance criteria can be met in different years. If distributional and abundance criteria are met for a five-year period the species will be considered restored. Delta smelt will meet the remaining recovery criteria and be considered for delisting when abundance and distributional criteria are met for a five-year period that includes two successive extreme outflow years, with one year dry or critical. Both criteria depend on data collected by the California Department of Fish and Game during the fall midwater trawl, during September and October (U.S. Fish and Wildlife Service 1996).*

*Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving into the Delta to spawn, by stimulating aquatic foodweb production to help ensure young delta smelt survival, and by providing transport flow to larval delta smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult delta smelt.*

## LONGFIN SMELT (R)

**TARGET**: Meet the goals of the Delta Native Fishes Recovery Plan which include recovery goals tied to the fall midwater trawl survey and the distribution of catch in various zones of the trawl survey, and catch goals in the Suisun Marsh trawl survey (◆◆).

**PROGRAMMATIC ACTION**: Restoration of longfin smelt will come indirectly from: increasing March to may Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; improving aquatic wetland and riparian habitats, and reducing stressors including the effects of water diversions, contaminants, and the stocking of striped bass and chinook salmon in longfin smelt nursery areas of North San Francisco Bay.

***RATIONALE**: General restoration objectives are the same as those described for delta smelt. Longfin smelt will be considered restored when its population dynamics and distribution patterns within the estuary are similar to those that existed in the 1967-1984 period. This period was chosen because it includes the earliest continuous data on* *longfin smelt abundances and was a period in which populations stayed reasonably high in most years.*

*Restoration of longfin smelt will be achieved when the species satisfies distributional and abundance criteria. Distributional criteria are: (1) longfin smelt must be captured in all zone 5 of 10 years, (2) in two zones for an additional year, and (3) at least one zone for 3 of the 4 remaining years, with no failure to meet site criteria in consecutive years. Abundance must be equal to or greater than predicted abundance for 5 of 10 years. Distributional and abundance criteria can be met in different years. If abundance and distributional criteria are met for a ten-year period, the species will be considered restored. Both criteria depend on data collected by the California Department of Fish and Game with the fall midwater trawl, during September and October (U.S. Fish and Wildlife Service 1996).*

*Meeting the targets of the Native Fish Recovery Plan will indicate an increase in the longfin smelt population. Without such an increase in the population, there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving into the Delta to spawn, by stimulating aquatic foodweb production to help ensure young longfin smelt survival, and by providing transport flow to larval longfin smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay.*

*Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult longfin smelt. Reevaluation of stocking striped bass and chinook salmon into prime nursery habitats of longfin smelt in San Pablo Bay and Suisun Bay would reduce predation on young longfin smelt. Alternative locations and time of stocking may limit predation on longfin smelt.*

## GREEN STURGEON (R)

**POPULATION TARGET**: Meet goals of the Delta Native Fishes Recovery Plan which includes 1,000 green sturgeon greater than 100 centimeters long as measured in the DFG mark-recapture program for estimating sturgeon abundance (◆◆).

**PROGRAMMATIC ACTION**: Restoration of green sturgeon will come indirectly from increasing March to May Delta inflow and outflow, improving Delta channel hydraulics, improving the Delta aquatic foodweb, and reducing stressors including effects of water diversions and contaminants.

**TARGET:** Restore access to habitat below Keswick Dam and increase the average annual abundance of adult green sturgeon to levels that will ensure the continued existence of this species (◆◆).

**PROGRAMMATIC ACTION:** Actions in the Sacramento River and San Joaquin River Ecological Management Zones have been designed specifically to restore green sturgeon, access to habitat below Keswick Dam, and habitat quality. This species will directly benefit from previously described actions in this zone to increase and improve streamflows, natural sediment supply, stream channel meander, and the area and distribution of riverine aquatic habitat.

These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- stream channel meander,
- riparian and riverine aquatic habitat,
- contaminants,
- water diversions, and
- dams, reservoirs, weirs, and other human-made structures.

Additional programmatic actions have been proposed in the Feather River/Sutter Basin, Sacramento-San Joaquin Delta, and Suisun

Marsh/North San Francisco Bay Ecological Management Zones that will contribute to restoring green sturgeon.

**RATIONALE**: *The primary objective is to maintain a minimum population of 1,000 fish over 1 meter (39 inches) total length each year, including 500 females over 1.3 meters (51 inches) total length (minimum size at maturity), during the period (presumably March-July) when spawners are present in the estuary and the Sacramento River. The restoration of green sturgeon should not be at the expense of other native fishes, including white sturgeon. The 1,000 number was determined as being near the median number of green sturgeon estimated to be in the Estuary during the 1980s. The total size of the adult green sturgeon population that uses the estuary may be larger than 1,000 because non-spawning adults may be in the ocean.*

*Green sturgeon will be considered restored in the Sacramento-San Joaquin estuary once the median population of mature individuals (over 1 meter total length) has reached 1,000 individuals (including 500 females over 1.3 meters total length) over a 50 year period or for five generations (10 years is the minimum age of sexual maturity). If population estimates are fewer that 1,000 fish for more than three years in a row, the restoration period will be restarted. (Note: This definition is subject to revision as more information becomes available.) Restoration will be measured by determining population sizes from tagging programs or other suitable means. The present sturgeon tagging programs, which focus on white sturgeon, are inadequate for determining accurately the abundance of green sturgeon. Therefore, a median population goal of 1,000 fish over 1 meter total length (including 500 females over 1.3 meters total length) is achievable with numbers determined through a monitoring program that focuses specifically on green sturgeon. Thus, the first restoration criterion will be establishment of an adequate population determination through a monitoring .program. Once that program is in place, the minimum population goals can be re-evaluated and a realistic, presumably higher, goal established. It may be desirable to have the numbers high enough to support the removal of a minimum of 50 fish over 1 meter total length per year by a fishery (assuming an exploitation rate of 5 percent is sustainable) (U.S. Fish and Wildlife Service 1996).*

*Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young sturgeon survival, and by providing transport flow to larval sturgeon to move them from the rivers into prime nursery habitat in the Delta and Suisun Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult sturgeon.*

## SPLITTAIL (R)

**POPULATION TARGET**: Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include recovery goals tied to the fall midwater trawl survey and distribution of catch in various zones of the trawl survey (◆◆).

**PROGRAMMATIC ACTION**: Restoration of splittail will come indirectly from increasing March to May Delta inflow which will increase spawning area availability, improving Delta water temperature, improving Delta channel hydraulics, improving the Delta aquatic foodweb, improving aquatic wetland, and riparian habitats, and reducing stressors including effects of water diversions and contaminants.

**TARGET**: Increase the average annual abundance and distribution of adult fish to levels that existed from 1967 to 1983 (◆◆).

**PROGRAMMATIC ACTION**: Actions in the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones have been designed specifically to restore splittail or their habitat. This species will directly benefit from actions in this zone to increase the area and distribution of riparian and riverine aquatic habitats and natural flood and floodplain processes. These programmatic actions address:

- riparian and riverine aquatic habitat, and
- natural flood and floodplain processes.

Additional restoration actions that will benefit splittail are proposed for the American River Basin, Yolo Basin, Feather River/Sutter Basin, Eastside Delta Tributaries, and San Joaquin River Ecological Management Zones.

***RATIONALE***: *Splittail will be considered restored when they meet two out of three possible restoration criteria, developed from three independent surveys. The three possible criteria are: (1) fall midwater trawl numbers must be 19 or greater for 7 of 15 years; (2) Suisun Marsh catch per trawl must be 3.8 or greater and catch of young-of-year must exceed 3.1 per trawl for 3 of 15 years; and (3) Bay Study otter trawl numbers must be 18 or greater and catch of young-of-year must exceed 14 for 3 out of 15 years. Within each survey, if target criteria are not met at least once in 5 consecutive years, the restoration period for the failed survey will be re-started. Criteria depend on data collected by three independent surveys, two conducted by the California Department of Fish and Game and on conducted by the University of California Davis. These studies were chosen because they sample most of the splittail range and contain the earliest continuous data on splittail abundance.*

*When any two out of three criteria are reached, splittail will be considered restored.*

- *Splittail will be considered restored when the fall midwater trawl exceeds 19 for 7 out of 15 years. If splittail fail to meet this restoration criterion for five consecutive years, the restoration period will start over.*
- *Splittail will be considered restored when Suisun Marsh catch per trawl exceed 3.8 for 7 out of 15 years and when splittail young abundance exceeds 3.1 per trawl for at least 3 out of 15 years. Splittail young abundance can be used to make up total abundance. If these target criteria (both young and overall) are not met for 5 consecutive years, the restoration period will begin again.*
- *Splittail will be considered restored when Bay Study otter trawl numbers exceed 18 for 7 out of 15 years and when splittail young numbers exceed 14 for 3 out of 15 years. Young-of-year numbers can be applied to meet overall criterion. If these targets, including both young-of-year and overall criteria, are not met for five consecutive years, the restoration period will be re-started (U.S. Fish and Wildlife Service 1996).*

*Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving upstream into the Delta and rivers to spawn, by increasing flooding of riparian vegetation and flood plain processes which provide important spawning habitat of splittail, by stimulating aquatic foodweb production to help ensure young splittail survival. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Improving shallow water, slough, and wetland habitats should increase the spawning and rearing habitat of splittail. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult splittail.*

## SACRAMENTO WINTER-RUN CHINOOK SALMON (R)

**POPULATION TARGET**: Meet the goals of the Winter-Run Chinook Salmon Recovery Plan and the Anadromous Fish Restoration Program (◆◆).

**PROGRAMMATIC ACTION**: Restoring chinook salmon populations will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; increasing shallow water, riparian, and wetland habitats in the Delta; and reducing stressors including effects of water diversions and contaminants.

**TARGET:** Restore the winter-run chinook salmon spawning population to levels that ensure its continued existence and allow for sport and commercial harvest (◆◆).

**PROGRAMMATIC ACTION:** Actions in the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zone have been designed specifically to restore winter-run chinook and its habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and winter-run chinook salmon directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, and weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

Additional programmatic actions that will contribute to the recovery of winter-run chinook salmon are proposed for the Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones. Programmatic actions proposed for Battle Creek in the North Sacramento Valley Ecological Management Zone have the potential to allow the future establishment of an addition population of winter-run chinook salmon.

***RATIONALE:*** *The goal of the Sacramento River winter-run chinook salmon is to establish a framework for the recovery of the population through a logical program of improving the habitat and environment of the species. Specifically, the recovery of this species requires actions which increase their abundance and improve their habitat to the point that the probability of subsequent extinction will be very low. When the underlying causes of the species' decline are no longer in effect and the species has rebounded to relatively healthy levels, winter-run chinook can be removed from the list of threatened and endangered species; that is, it can be "delisted."*

*An extinction model was used to develop the delisting criteria to ensure a low probability of extinction once the criteria have been reached. The risk level chosen was a probability of less than 0.1 within the 50 years following delisting. Assurance of the probability of extinction required specification of the population growth rate in addition to population abundance. The delisting criteria for winter-run chinook follow:*

*Population Criteria: the mean annual spawning abundance over any 13 consecutive years shall be 10,000 females (or a total spawning run of more than twice the female spawning abundance). The geometric mean of the Cohort Replacement Rate over those same 13 years shall be greater than 1.0. Estimates of these criteria shall be based on natural production alone and shall not include hatchery-produced fish. The variability in Cohort Replacement Rate is assumed to be the same as or less than the current variability. In addition, there must be a system in place for estimating spawning run abundance with a standard error less than 25% of the estimate, on which to base the calculation of the population criteria. If this level of precision cannot be achieved, then the sampling period over which the geometric mean of the Cohort Replacement Rate is estimated must be* *increased by one additional year for each 10% of additional error above 25% (National Marine Fisheries Service 1997).*

*Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young survival, and by providing transport flow to juvenile salmon to move them from the rivers into prime nursery habitat in the Delta and Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult salmon.*

## SACRAMENTO SPRING-RUN CHINOOK SALMON (R)

**POPULATION TARGET:** Maintain the average cohort replacement rate of Sacramento spring-run chinook salmon above 1.0 while the stock is rebuilding. Then maintain a replacement rate equal to or greater than 1.0 when the stock reaches restoration goal levels set by the regulatory agencies (◆◆).

**PROGRAMMATIC ACTION:** Actions in the Sacramento River, North Sacramento Valley, Cottonwood Creek, Butte Basin, Feather River/Sutter Basin, and Sacramento-San Joaquin Delta Ecological Management Zones have been designed to achieve the recovery spring-run chinook and its habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and spring-run chinook salmon directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

***RATIONALE:*** *Spring-run chinook salmon are listed as a threatened species under the California Endangered Species Act and proposed for listing under the ESA. Because of their life history patterns, spring-run chinook enter the Sacramento River early in the year and ascend to tributaries where they oversummer to spawn during the following fall. Young fish may rear for a year or longer in the tributaries before entering the Sacramento River during their seaward migration.*

*The status of a spring-run chinook salmon in the mainstem Sacramento River is uncertain, however, evidence suggests that there may be a significant introgression with fall-run chinook. The role of the Sacramento River in sustaining spring-run chinook salmon is primarily to provide adult fish passage to the tributary streams and to provide rearing and emigration habitat for juveniles during their seaward migration.*

*Natural populations and their essential habitat must be sufficiently abundant to ensure Sacramento River spring-run chinook salmon's long-term survival. In order to achieve recovery, the remaining natural, non-introgressed populations of spring run and any re-established natural populations must be protected, monitored, and proven to be self-sustaining to the satisfaction of the Department of Fish and Game and the Fish and Game Commission. Recovery goals must ensure that the individual populations, as well as the collective metapopulation, are sufficiently abundant to avoid genetic risks of small population size. Thus, recovery goals need to address abundance levels (adult spawning escapements), population stability criteria, population distribution, and length of time for determining sustainability.*

*The California Department of Fish and Game's recovery objectives for Sacramento River spring-run chinook salmon are (1) the protection and enhancement of the existing natural populations; (2) the re-establishment of additional, viable native populations; and (3) the restoration and protection of natal, rearing, and migratory streams within the Sacramento River basin (California Department of Fish and Game 1998).*

*The U.S. Fish and Wildlife Service (1996) has recommended restoration objectives and criteria for Sacramento River spring-run chinook salmon based on the objective of establishing self-sustaining populations which will persist indefinitely for each species addressed. Additionally, the population goals for chinook salmon runs include extra adult production for allowing sustained limited harvests of each run. The plan states that restoration will be measured by three interacting criteria: (1) presence of self-sustaining spawning populations in Mill and Deer creeks; (2) total number of spawners in Mill, Deer, Antelope, Butte, Big Chico, Beegum, South Fork Cottonwood, and Clear creeks (if the Yuba River proves to still have a natural run of spring-run chinook, the population goal should be raised by whatever number of spawners the stream can support); and (3) smolt survival through the Delta.*

*Spring-run chinook salmon populations will be considered healthy when the average number of spawners in tributary streams to the Sacramento River exceeds 5,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry. The average number of natural, wild spawners over the 15-year period must not be fewer than 8,000 fish (USFWS 1996).*

## SACRAMENTO LATE-FALL-RUN CHINOOK SALMON (R)

**POPULATION TARGET:** Maintain the average cohort replacement rate of late-fall-run chinook salmon above 1.0 while the stock is rebuilding. Then maintain a replacement rate equal to or greater than 1.0 when the stock reaches restoration goal levels set by the regulatory agencies (◆◆).

**PROGRAMMATIC ACTION:** Actions in the Sacramento River, North Sacramento Valley, and Sacramento-San Joaquin Delta Ecological Management Zones have been designed specifically to restore late-fall-run chinook and its habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and late-fall-run chinook salmon directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, and weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

Additional programmatic actions that will contribute to the recovery of late-fall-run chinook salmon are proposed for the Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones.

***RATIONALE:*** *Presently, late-fall-run chinook salmon have no special protection. The great majority of late-fall-run chinook appear to spawn in the mainstem Sacramento River during January, February, and March. Late-fall-run chinook abundance has declined due to passage problems at Red Bluff Diversion Dam, loss of habitat, poor survival of emigrating smolts, sport and commercial harvest, and other factors, such as disease and pollutants.*

*Sacramento River late-fall-run chinook salmon populations will be regarded as healthy when the average number of spawners in the Sacramento River basin exceeds 15,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry (U.S. Fish and Wildlife Service 1996).*

## FALL-RUN CHINOOK SALMON (R)

**POPULATION TARGET:** Maintain the average cohort replacement rate of Sacramento fall-run chinook salmon above 1.0 while the stock is rebuilding. Then maintain a replacement rate equal to or greater than 1.0 when the stock reaches restoration goal levels set by the regulatory agencies (◆◆).

**PROGRAMMATIC ACTION:** Actions in many of the Ecological Management Zones have been designed specifically to restore fall-run chinook and its habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and fall-run chinook salmon directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, and weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

Additional programmatic actions that will contribute to the restoration of fall-run chinook salmon are proposed for the North Sacramento Valley, Butte Basin, Colusa Basin, Cottonwood Creek, Feather River/Sutter Basin, American River, Eastside Delta Tributaries, East San Joaquin, Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones.

**RATIONALE:** *Because of their life-history requirements, typical of all Pacific salmon, Central Valley chinook salmon require high-quality habitats for migration, holding, spawning, egg incubation, emergence, rearing, and emigration to the ocean. These diverse habitats are still present throughout the Central Valley and are successfully maintained to varying degrees by existing ecological processes. Even though the quality and accessibility of the habitats have been diminished by human-caused actions, these habitats can be restored through a comprehensive program that strives to restore or reactivate ecological processes, functions, and habitat elements on a systematic basis, while reducing or eliminating known sources of mortality and other stressors that impair the survival of chinook salmon.*

*There are three major programs to restore chinook salmon populations in the Central Valley. The Secretary of the Interior is required by the Central Valley Project Improvement Act (PL 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995). The National Marine Fisheries Service is required under the federal ESA to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species (NMFS 1996). The California Department of Fish and Game is required under state legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993).*

*Each of the major chinook salmon restoration /recovery programs has developed specific goals for Central Valley chinook salmon stocks. ERPP* *embraces each of the restoration/recovery goals and will contribute to each agency's program by restoring critical ecological processes, functions, and habitats, and by reducing or eliminating stressors. ERPP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0 while the individual stocks are rebuilding to desired levels. When the stocks approach the desired population goals, ERPP will contribute to maintaining a cohort replacement rate of 1.0.*

## STEELHEAD TROUT (R)

**POPULATION TARGET**: Increase naturally spawning population number and sizes sufficient to maintain population resiliency and to allow meta-population persistence through periods of adverse climatic and ecological conditions. This would entail, at a minimum, restoring and maintaining viable populations in the upper Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, and Battle, Clear, Big Chico, Butte, Antelope, Mill, and Deer creeks (◆◆).

**PROGRAMMATIC ACTION**: Restoring steelhead trout populations will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; increasing shallow water, riparian, and wetland habitats in the Delta; and reducing stressors including effects of water diversions and contaminants.

Actions in the Sacramento River Ecological Management Zone have been designed specifically to restore steelhead or their habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and steelhead directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, and weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

Additional programmatic actions that will contribute to the recovery of steelhead are proposed for the North Sacramento Valley, Cottonwood Creek, Colusa Basin, Butte Basin, Feather River/Sutter Basin, American River, Eastside Delta Tributaries, San Joaquin River East San Joaquin, Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones.

***RATIONALE:*** *NMFS has identified steelhead populations in the Central Valley as composing a single evolutionarily significant unit (ESU) based on a variety of physical and biological data. These data include the physical environment (geology, soil type, air temperature, precipitation, riverflow patterns, water temperature, and vegetation); biogeography (marine, estuarine, and freshwater fish distributions); and life history traits (age at smolting, age at spawning, river entry timing, spawning timing, and genetic uniqueness).*

*The Central Valley steelhead ESU encompasses the Sacramento River and its tributaries and the San Joaquin River and its tributaries downstream of the confluence with the Merced River (including the Merced River). Recent data from genetic studies show that samples of steelhead from Deer and Mill creeks, the Stanislaus River, Coleman National Fish Hatchery on Battle Creek, and Feather River Hatchery are well differentiated from all other samples of steelhead from California Busby et al. 1996; NMFS 1997).*

*Within the broad context of ecosystem restoration, steelhead restoration will include a wide variety of efforts, many of which are being implemented for other ecological purposes, or that are nonspecific to steelhead trout. For example, restoration of riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetation/successional processes. These will be extremely important in providing shaded riverine aquatic habitat, woody debris, and other necessary habitats required by lower trophic organisms and juvenile and adult steelhead populations.*

*Operation of the water storage and conveyance systems throughout the Central Valley for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including steelhead trout. Inadequate connectivity between upstream holding, spawning, and rearing habitat in certain tributary streams has impaired or reduced the reproductive potential of most steelhead stocks. Providing stream flows, improving fish ladders, and removing dams will contribute greatly to efforts to rebuild steelhead populations.*

***Strategic Plan Priority Group II:*** At-risk native species dependent on the Bay-Delta system whose restoration is not likely to require large-scale manipulations of ecosystem processes because they have limited habitat requirements in the estuary and watershed (e.g., brackish water plants).

## LAMPREY FAMILY

**POPULATION TARGET**: Evaluate the status and life history requirements of Pacific lamprey and river lamprey in the Central Valley and determine their use of the Delta and Suisun Bay for migration, breeding, and rearing (◆◆).

**PROGRAMMATIC ACTION**: Actions directed to remediate stream flow deficiencies, water temperatures, sediment transport, fish passage, and water quality will contribute to maintaining and increasing lamprey populations in Central Valley rivers and streams.

***RATIONALE**: Lampreys are anadromous species that clearly have declined in the Central Valley although the extent of the decline has not been documented. Pacific lamprey probably exist in much of the accessible habitat available today but this is not known. The decline of lampreys is presumably due to deterioration of their spawning and rearing habitat, to entrainment in diversions, and to other factors affecting fish health in the system.*

## CALIFORNIA CLAPPER RAIL (r)

**POPULATION TARGET:** Restore sufficient saltmarsh habitat to connect and combine separated saltmarsh habitat areas that support California clapper rail populations. This will enlarge protected areas and reduce intermarsh distances (◆◆).

**PROGRAMMATIC ACTION:** Restoring saltmarsh and tidal emergent wetland habitat would directly benefit the California clapper rail population. Reduction in boat wakes which disturb nesting rails would also contribute to recovery.

***Rationale:** The primary reason attributable to the decline in California clapper rail populations is the extensive loss of its historical salt marsh habitat to urban, industrial, and agricultural uses (U.S. Fish and Wildlife Service 1984a). Restoration of large expanses of suitable salt marsh habitat within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

## California Black Rail(r)

**Population Target**: Enhance and restore tidal marshes and adjacent perennial grassland habitats in the Delta (◆◆).

**Programmatic Action:** Restoring tidal marsh habitat would indirectly benefit California black rail population. Actions to reduce boat wake disturbance would also contribute to recovery.

***Rationale:*** *The primary reason attributable to the decline in California black rail populations is the extensive loss of its historical tidal marsh habitat to urban, industrial, and agricultural uses. Restoration of large expanses of suitable tidal marsh habitat within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

## Swainson's Hawk (r)

**Population Target**: Restore nesting density to nine nesting pairs per 100 square miles; improve foraging habitat on Delta land; and increase riparian forest and oak woodlands (◆◆◆).

**Programmatic Action:** Restore riparian woodlands and improve wildlife habitat values on agricultural lands.

***Rationale:*** *Historically, Swainson's hawk foraging habitat consisted of large expanses of open grasslands that supported abundant prey species. Swainson's hawks typically nest in riparian forests, small groves of trees, or lone trees within open habitats. Today, as a result of conversion of large expanses of historic grassland to urban, industrial, and agricultural uses, agricultural lands are major foraging habitat areas for Swainson's hawks. Some types of agriculture, however, are unsuitable because they do not support sufficient prey populations or because prey is unavailable as a result of dense vegetation (e.g., rice and vineyards). Over 85% of nesting territories in the Central Valley are associated with riparian systems adjacent to suitable foraging habitats (California Department of Fish and Game 1992). Consequently, improving prey abundance and availability on agricultural lands adjacent to restored riparian habitats will provide important elements of the specie's habitat necessary for the population to expand.*

## Suisun Song Sparrow (R)

**Population Target:** Increase the population of breeding pairs of Suisun song sparrow between 70 and 100 percent compared to existing population estimates of 6,000 (◆◆).

**Programmatic Action**: Encourage the growth of upland vegetation on the upper banks of levees to provide upland cover to protect against predation during high tides and high flows.

**Programmatic Action**: Establish additional and protect existing dispersal corridors of suitable tidal brackish marsh along the banks of tidal sloughs.

**Programmatic Action**: Maintenance activities should be conducted to minimize disturbance to tidal brackish marsh vegetation and should not disturb breeding adults.

**Programmatic Action**: Restore tidal habitat as specified for tidal saline emergent wetland in appropriate areas with particular emphasis on expanding existing fragments of habitat to expand the number of known nesting territories in the Suisun Marsh by 100 percent.

***Rationale:*** *The Suisun song sparrow occurs only in and near Suisun Marsh, in about 13 isolated populations. Populations of this unusual subspecies are declining for a variety of reasons but mainly the degradation of their habitat. Reductions in fresh water outflow from the Sacramento-San Joaquin Rivers and diking and channelization of marsh lands have contributed to their decline. Restoration of their populations is* *likely to be a good indicator of the success of restoration of brackish tidal marshes in the Suisun Marsh area.*

## ALAMEDA SONG SPARROW (nc)

**POPULATION TARGET**: Connect fragmented habitat to increase gene flow between populations. Conduct genetic studies as well as juvenile dispersal studies to determine effective management of the species (◆◆).

**PROGRAMMATIC ACTION**: All Alameda song sparrow populations will have been identified and protected from further development and habitat alteration. Pilot restoration projects will have been undertaken to develop protocols for habitat restoration efforts.

***RATIONALE**: Alameda song sparrows are one of the species that uses saltmarsh habitat in the south San Francisco Bay region. By protecting the saltmarsh habitat not only will this species benefit but the other inhabitants of the marsh ecosystem will also benefit. Restoration of this species would be a good indicator to the overall health of the marsh system.*

## SALT MARSH HARVEST MOUSE (r)

**POPULATION TARGET:** Increase the existing population by 100% (◆◆).

**PROGRAMMATIC ACTIONS:** Restore high tidal marsh habitats in proximity to upland habitats in the Suisun Marsh/North San Francisco Bay Ecological Management Zone consistent with the recovery plan for this species.

***RATIONALE:** The primary reason attributable to the decline in salt marsh harvest mouse populations is the extensive loss of its historical high tidal salt marsh and adjacent upland habitats to urban, industrial, and agricultural uses (U.S. Fish and Wildlife Service 1984a). Restoration of large expanses of suitable salt marsh habitat adjacent to uplands within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

## SUISUN ORNATE SHREW (R)

**POPULATION TARGET**: Identify the remaining populations of Suisun ornate shrew and develop a conservation plan to stop the decline of this species (◆◆).

**PROGRAMMATIC ACTION**: Identify all remaining populations of Suisun ornate shrew and develop and implement protection/restoration plans.

***RATIONALE**: The Suisun ornate shrew is a listed as a species of special concern by the California Department of Fish and Game, but its limited habitat and distribution indicate it may qualify as a threatened species. Long-term survival of this subspecies is dependent upon tidal wetland, as opposed to diked wetlands, and has to have adequate physical structures and plant communities for survival. Its tidal marsh habitat has to have adjacent upland habitat for survival of the species during periods when the marsh is inundated. The upland habitat has to have relatively low densities of exotic predators. Restoring habitat would not only benefit the Suisun ornate shrew but other species, such as the salt marsh harvest mouse, that also use tidal marsh and upland marsh habitats.*

## SAN PABLO CALIFORNIA VOLE (r)

**POPULATION TARGET**: Determine the distribution and taxonomic status of the vole while maintaining existing salt marsh habitat known to contain populations (◆◆).

**PROGRAMMATIC ACTION**: Undertake wetland restoration projects in and adjacent to known populations to increase available habitat.

***RATIONALE**: The San Pablo vole is a California Department of Fish and Game Special Concern species. Although little is known about its* *distribution, biology, or taxonomy, it appears to be a distinct form that is confined to salt marshes and adjoining grasslands in Contra Costa County. To limit the decline of the populations even further, salt marsh and adjoining grassland habitats in Contra Cosa County need to be protected and further degradation and loss of habitat halted.*

## VALLEY ELDERBERRY LONGHORN BEETLE (R)

**POPULATION TARGET**: Protect known occupied habitat and suitable habitat within the suspected historical range of the valley elderberry longhorn beetle from loss or degradation (◆◆).

**PROGRAMMATIC ACTION**: Survey riparian vegetation along Central Valley rivers to determine the presence of additional populations and protect occupied habitat areas from activities detrimental to the valley elderberry longhorn beetle.

Programmatic actions designed to protect, restore, and enhance riparian habitats along Central Valley rivers, including elderberry shrubs (the valley elderberry longhorn beetle's host plant), will protect existing occupied habitat areas and increase the area of suitable habitat within the species suspected historical range.

**RATIONALE**: *The primary reason attributable to the decline in numbers and distribution of the valley elderberry longhorn beetle populations is the extensive loss or degradation of its historical riparian habitats in the Central Valley to urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1984b). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

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***Priority Group III:*** At-risk species that primarily live upstream of the estuary or in local watersheds of San Francisco Bay.

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## SACRAMENTO PERCH (r)

**POPULATION TARGET**: Evaluate the status and biology of Sacramento perch to determine if restoration of wild populations within its native range is feasible (◆).

**PROGRAMMATIC ACTION**: Complete a thorough status review of the Sacramento perch and develop a plan for its long-term preservation in the Central Valley. Establish at least one experimental population in the Delta.

***RATIONALE:*** *The Sacramento perch was once one of the most abundant fish in lowland habitats of the Central Valley. With the exception of a small population in Clear Lake, it has been extirpated from natural habitats within its native range due to competition and predation from introduced centrarchid fishes, such as black bass. It would be certainly be formally listed as an endangered species except that it has been widely introduced into reservoirs, lakes, and ponds outside its native habitats in California and other western states.*

## RIPARIAN BRUSH RABBIT (r)

**POPULATION TARGET**: Establish five additional populations and increase the population of riparian brush rabbits by 200 percent over current estimates so that a census of the riparian brush rabbit population would be two times higher than the current estimate of 213 to 312 individuals (◆◆).

**PROGRAMMATIC ACTION:** Reestablish 500 acres of large contiguous areas of riparian forest habitat that have dense brushy understories with adjacent upland habitat. These restored/reestablished riparian forests would have adjacent upland habitat with sufficient cover. Establish five additional populations elsewhere within the historic range of the riparian brush rabbit; each population should have a self-sustaining populations with a minimum of 250 individuals each. Maintain and establish connectivity between key habitats.

**PROGRAMMATIC ACTION:** Prohibit ground cover and litter removal to allow for dense brushy and herbaceous areas of a minimum size of 550 square yards within the riparian forest.

**PROGRAMMATIC ACTION:** More closely approximate the natural hydrological regime which allows for establishment and maintenance of mature riparian forest habitat. Additionally, encourage growth of wild rose, coyote bush, blackberries, elderberries, wild grape, box elder, valley oak, and cottonwoods to provide habitat.

**PROGRAMMATIC ACTION:** Provide high ground adjacent to current and expanded habitat with cover for protection from floods. Existing flood control levees adjacent to the Park could be utilized for this escape habitat in this area to provide sufficient vegetative growth of grasses, forbs, and shrubs to lower predation pressure during these times.

**PROGRAMMATIC ACTION:** Provide fire breaks around current and expanded habitat to protect habitat destruction due to wildfire and control feral cat and dog population with yearly control efforts within and adjacent to the Park. Prohibit dogs within Caswell Memorial State Park.

***RATIONALE:*** *Protection and restoration of existing occupied riparian brush rabbit habitat at Caswell Memorial State Park and actions to reduce the probability for mortality as a result of flooding, fire, and predation are major objectives of the species recovery plan (U.S. Fish and Wildlife Service 1997).*

## SAN JOAQUIN VALLEY WOODRAT (r)

**POPULATION TARGET:** Increase the population sizes along the San Joaquin River in Stanislaus, Merced, and San Joaquin Counties to the point where the woodrat will no longer be regarded as threatened (◆◆).

**PROGRAMMATIC ACTION:** Actions to protect and restore riparian brush rabbit habitat at Caswell Memorial State Park where the only known San Joaquin valley woodrat population occurs and actions that will restore and protect riparian habitat along the San Joaquin River and its tributaries within the species current and historical range will benefit this species.

***RATIONALE:*** *The primary reason attributable to the decline in numbers and distribution of the San Joaquin Valley woodrat populations is the extensive loss and fragmentation of its historical riparian habitats in the San Joaquin Valley urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1997). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

## GREATER SANDHILL CRANE (r)

**POPULATION TARGET:** Establish two new suitable roosting habitat areas in the Delta; enhance foraging habitat on agricultural lands; restore perennial grasslands in the East Delta Ecological Management Unit, and restore seasonally managed nontidal marshes in the East Delta Ecological Management Unit (◆◆◆).

**PROGRAMMATIC ACTIONS:** Restoring nontidal emergent wetland, perennial grasslands, seasonal wetlands, and agricultural foraging habitat would indirectly benefit the greater sandhill crane population.

**RATIONALE:** *Suitable shallow-water roosting habitat used by greater sandhill cranes during winter in the Delta is limited. Restoration and management of seasonal wetlands specifically to provide suitable roosting habitat free from disturbance near suitable foraging habitats will increase the area of available roosting habitat and may improve distribution of wintering cranes. Increases in food availability and abundance on agricultural lands will also be likely to improve distribution and winter survival of cranes in the Delta.*

### CALIFORNIA YELLOW WARBLER (r)

**POPULATION TARGET**: Increase breeding populations and develop restoration projects that will benefit migrating individuals (◆◆).

**PROGRAMMATIC ACTION**: Actions to protect and restore riparian habitats used by the California yellow warbler will increase the quantity and quality of habitat for this species.

**RATIONALE**: *Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds. Improved habitat for songbirds also provides habitat for many other species of animals and plants.*

### WESTERN LEAST BITTERN (r)

**POPULATION TARGET**: Develop wintering habitat for least bitterns by creating "no disturbance" refuges along the central corridor of the Central Valley and Delta for all shore and wading birds (◆◆).

**PROGRAMMATIC ACTION**: Conduct a thorough review of the status and habitat requirements of western least bittern. Establish "no disturbance" refuges to protect wintering habitat of bitterns and other wading and shore birds from human disturbance.

**RATIONALE**: *The western least bittern, a California Department of Fish and Game Species of Special Concern nests in emergent wetlands of cattails and tules in the upper and lower reaches of the Central Valley and winters in marshlands along the main rivers and in the Delta. Least bitterns were apparently once a common wintering bird in the Central Valley but are now scarce. The loss of wintering habitat as a result of channelization and reclamation of marsh lands along the major rivers and Delta has been a major factor in their decline.*

### LEAST BELL'S VIREO (r)

**POPULATION TARGET**: Recover least Bell's vireo populations to the point where it can be removed from state and federal endangered species lists (◆).

**PROGRAMMATIC ACTION**: Actions to protect and restore suitable riparian habitat within the historical range of the least Bell's vireo in the Central Valley will increase the quantity and quality of suitable habitat available to accommodate the potential future expansion of the species current range.

***RATIONALE:*** *A major reason attributable to the extirpation of the least Bell's vireo from its historical range in the Central Valley is the extensive loss and fragmentation of its historical riparian habitats to urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1998). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical range is an objective of the least Bell's vireo recovery plan (U.S. Fish and Wildlife Service 1998) and will provide habitat area necessary for existing populations to expand.*

### WESTERN YELLOW-BILLED (r) CUCKOO

**POPULATION TARGET**: Improve riparian forest habitat in the Delta (◆◆).

**PROGRAMMATIC ACTIONS:** Improve and restore riparian forest habitat.

**TARGET:** Protect existing large patches and restore suitable mature, dense willow-cottonwood riparian forests used by nesting cuckoos (◆◆).

**PROGRAMMATIC ACTION:** The primary focus area for restoration of the yellow-billed cuckoo is the Delta. No actions in the Sacramento River Ecological Management Zone have been designed specifically to restore yellow-billed cuckoos or their habitat. However, this species will directly benefit from actions in this zone to increase the areal extent and distribution of riparian and riverine aquatic habitats (see implementation objective, targets, and programmatic actions that address riparian and riverine aquatic habitat).

***RATIONALE:*** *The primary reason attributable to the decline in numbers and distribution of the western yellow-billed cuckoo is the extensive loss or degradation of its historical riparian forest habitats in the Central Valley to urban and agricultural uses, and flood control and water supply projects to support those uses (California Department of Fish and Game 1992). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

### BANK SWALLOW (r)

**POPULATION TARGET:** Protect existing nesting colonies and the ecological processes that contribute to the formation and maintenance of vertical stream banks (◆◆).

**PROGRAMMATIC ACTIONS:** No actions in the Sacramento River Ecological Management Zone have been designed specifically to restore bank swallows or their habitat. However, this species will directly benefit from actions in this zone to increase the areal extent and distribution of riparian and riverine aquatic habitats, stream channel corridor, natural flood and floodplain processes, and natural sediment supply (see implementation objective, targets, and programmatic actions that address riparian and riverine aquatic habitats, stream channel corridor, natural flood and floodplain processes, and natural sediment supply).

***RATIONALE:*** *The decline in numbers and distribution of bank swallow populations is attributable to the loss of the natural depositional and erosional processes of rivers that create and sustain the types of channel bank nesting substrates required by the species largely as a result of flood control projects that have impeded the ability of rivers to erode their banks (California Department of Fish and Game 1992). Restoration of the ability of channels of major rivers in the Central Valley to erode their banks will increase the availability of suitable nesting habitat, providing the additional habitat area necessary for existing populations to expand.*

## LITTLE WILLOW FLYCATCHER (r)

**POPULATION TARGET**: Establish enough self-sustaining populations of little willow flycatcher so that the species can be removed from the state list of endangered species (◆).

**PROGRAMMATIC ACTION**: Actions to protect and restore suitable riparian habitat within the historical breeding range of the little willow flycatcher in the Central Valley will increase the quantity and quality of suitable habitat available to accommodate the potential future expansion of the species current range.

***RATIONALE**: A major reason attributable to the extirpation of the little willow flycatcher as a breeding species from its historical range in the Central Valley is the extensive loss and fragmentation of its historical riparian habitats to urban and agricultural uses, and flood control and water supply projects to support those uses (Zeiner et al. 1990, California. Department of Fish and Game 1992). Consequently, the protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical range will provide habitat area necessary for existing populations to expand.*

## GIANT GARTER SNAKE (r)

**POPULATION TARGET**: Maintain present populations with no further declines in size by ensuring that waterways known to being used by giant garter snakes have water in them year round (◆◆).

**PROGRAMMATIC ACTION**: Maintain existing natural habitats that have available water all year and identify key habitats in agricultural areas for special management.

***RATIONALE**: The giant garter snake is listed by both state and federal governments as a threatened species. Most of the original giant garter snake habitat, freshwater marshes, has been lost to agriculture. This snake resides in marsh habitat where there are pools and sloughs that exist year round to provide the frogs and invertebrates on which they feed. This snake survives today because small numbers live in rice fields and along irrigation ditches. Survival of the species, however, is likely to depend upon increasing its natural habitat through marsh restoration combined with special protection measures on the agricultural land it currently inhabits.*

## CALIFORNIA RED-LEGGED FROG (r)

**POPULATION TARGET**: Create viable, self-sustaining populations of red-legged frog while enhancing existing and restored aquatic habitats for other native species (◆).

**PROGRAMMATIC ACTION 1A:** Develop watershed management plans to protect riparian and wetland areas occupied by red-legged frogs.

**TARGET:** Manage restored aquatic and wetland habitat to minimize predation on red-legged frog by non-native fish, bullfrogs, and crayfish (◆).

**PROGRAMMATIC ACTION:** Reduce exotic predators such as bullfrogs, black bass, sunfish, and crayfish and restore habitat by creating canals, side channels, and backflow pools containing emergent vegetation. Provide the critical components of reproductive, forage and escape cover.

***RATIONALE:** Red-legged frogs are virtually extinct in the region, with just a handful of tenuous populations remaining in the Central Valley and bay region (none near the estuary). Their inability to recover from a presumed major population crash in the 19th century (due to overexploitation) has been the result of a combination of factors (in approximate order of importance): (1) predation and competition from introduced bullfrogs and fishes; (2) habitat loss, (3) pesticides and other toxins, (4) disease, and (5) other factors. Because of the poor condition of the few remaining frog populations and the continued existence of major* *causes of their decline, this objective may not be achievable in either the short or long term.*

## CALIFORNIA TIGER SALAMANDER (m)

**POPULATION TARGET**: Increase populations of tiger salamanders by increasing natural flood plains, stream meander, seasonal pools, and perennial grasslands (◆).

**PROGRAMMATIC ACTIONS:** The California tiger salamander will benefit indirectly from restoration of natural flood plains. A regulated management grazing program could benefit vernal pool habitats that support these species. Mowing and cattle grazing should be minimized near seasonal wetlands utilized by either species from October to March. Reduce mortality from vehicle deaths, especially during the brief window when tiger salamanders are migrating by locating restored habitat in areas well removed from regular vehicle traffic. Fumigants to control rodents should be used only from October to March in known occupied habitats since rodent burrows are required during the summer. Draining pertinent water ways during the native species' dormant season could result in a reduction in populations of large, introduced, predatory fish and bullfrogs.

Restore at least five core areas of suitable habitat, each consisting of about 500 acres in each of the North, East, and South Delta Ecological Management Units.

**PROGRAMMATIC ACTIONS:** Enhance existing poor habitats and restore new habitats in historical wetlands, grasslands, and upland areas.

***RATIONALE:*** *California tiger salamander populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat containing rodent burrows in which they can over-summer. Patches of suitable habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to local conditions. Long-term survival of these diverse populations depends on numerous protected areas containing both breeding ponds and upland habitats.*

## WESTERN POND TURTLE (m)

**POPULATION TARGET**: Determine the status and habitat requirements of pond turtles throughout the region and develop a conservation strategy in concert with habitat protection measures (◆◆).

**PROGRAMMATIC ACTION**: Locate and protect populations of turtles that appear to still have successful reproduction. Causes of the decline should be determined and a recovery plan developed based on the findings.

***RATIONALE:*** *The western pond turtle is the only turtle native to the Central Valley region and to much of the western United States. Although considered to be just one widely distributed species, it is likely that the pond turtle is a complex of closely related species, each adapted for a different region. The Pacific pond turtle is still common enough in the Bay-Delta watershed so that it is not difficult to find them in habitats ranging from sloughs of the Delta and Suisun Marsh to pools in small streams. The problem is that most individuals seen are large, old individuals; hatchlings and small turtles are increasingly rare. The causes of the poor reproductive success are not well understood but factors that need to be considered include elimination of suitable breeding sites, predation on hatchlings by non-native predators (e.g., largemouth bass, bullfrogs), predation on eggs by non-native wild pigs, diseases introduced by non-native turtles, and shortage of safe upland over-wintering refuges. If present trends continue, the western pond turtle will deserve listing as a threatened species (it may already).*

## Delta Green Ground Beetle (r)

**Population Target:** Expand the existing population of Delta green ground beetle and establish additional populations to remove it from the Federal threatened species list (◆◆).

**Programmatic Actions:** Increase populations of Delta Green Ground Beetle by establishing and securing habitat to support three additional viable and self-sustaining colonies of the Delta green ground beetle and maintain the existing populations.

***Rationale:*** *The Delta green ground beetle is federally listed as a threatened species that is currently known only from Jepson Prairie Preserve (Solano County). Habitat requirements for this species are not clearly understood but the beetles seem to require open places near vernal pools. A better knowledge would help restoration efforts.*

## Lange's Metalmark Butterfly (R)

**Population Target:** Create multiple populations of Lange's metalmark butterfly within the Antioch Dunes region (◆◆).

**Programmatic Action:** Actions for protecting and restoring inland dune scrub habitat occupied by the Lange's metalmark at the Antioch Dunes will benefit this species.

***Rationale:*** *Protection and restoration of Lange's metalmark habitat at the Antioch Dunes is a major objective of the species recovery plan (U.S. Fish and Wildlife Service 1984c).*

## California Freshwater Shrimp (m)

**Population Target:** Maintain California freshwater shrimp population abundance and distribution consistent with the recovery plan (◆).

**Programmatic Action:** Protect and restore habitat required by the California freshwater shrimp including low elevation, low gradient perennial freshwater streams or intermittent streams with perennial pool where banks are structurally diverse with undercut banks, exposed roots, overhanging woody debris, or overhanging vegetation.

***Rationale:*** *The recovery objectives for California freshwater shrimp are: (1) to recover and delist the shrimp when viable, self-sustaining populations and their habitat are secured an managed within all watershed harboring shrimp, and (2) to enhance habitat conditions for aquatic organisms that currently coexist or have occurred historically with the California freshwater shrimp.*

*Downlisting from endangered to threatened will be considered when: (1) a watershed plan has been implemented for each of four drainage units, (2) long-term protection is assured for at least one shrimp stream in each of the four drainage units, and (3) the abundance of California freshwater shrimp increases to over 2,000 individuals per stream in each of 16 streams harboring shrimp.*

*Delisting of California freshwater shrimp will be considered when: (1) a watershed plan has been implemented for each of four drainage units, (2) long-term protection is assured for at least eight shrimp stream with at least one in each of the four drainage units, (3) populations of California freshwater shrimp maintain stable or increasing populations of at least 2,000 individuals for at least 10 years in each of 16 streams harboring shrimp, and (4) at least 50 percent of shrimp-bearing streams have shrimp distributed over 8 kilometers (5 miles) or more (U.S. Fish and Wildlife Service 1997b).*

***Strategic Plan Priority Group IV:*** Native species in the estuary and watershed not yet at risk of extinction that have the potential to achieve that status if steps are not taken to reverse their declines or keep populations at present levels.

## NATIVE RESIDENT FISHES (nc)

**POPULATION TARGET**: Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include improving habitat of native fishes and restoring the population of Sacramento perch (◆).

**PROGRAMMATIC ACTION**: Restoration of native resident species will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; improving aquatic, wetland, and riparian habitats; and reducing stressors including effects of water diversions and contaminants.

***RATIONALE:*** *The Central Valley has a native resident fish fauna that is largely endemic to the region. Some species are extinct (thicktail chub) or nearly extinct (Sacramento perch) in the wild. While some native species (e.g., Sacramento pikeminnow [squawfish], Sacramento sucker) are clearly thriving under altered conditions, others are not (e.g., hitch, Sacramento blackfish, hardhead). There is a need to determine if some have unique problems or requirements that will prevent them from responding to general habitat improvements.*

## WATERFOWL (nc)

**POPULATION TARGET**: Improve populations and distribution of waterfowl (◆◆).

**PROGRAMMATIC ACTIONS:** Waterfowl will indirectly benefit from restoration of sloughs, marshes, riparian, and tidal and nontidal ponds and lakes.

***RATIONALE:*** *Waterfowl resources will be enhanced by protecting existing and restoring additional seasonal, permanent, and tidal wetlands. Improved management of agricultural lands using wildlife friendly methods will contribute to sustaining waterfowl resources in the Bay-Delta. The focus for seasonal wetlands should be in areas that may be too deep for tidal marsh restoration over the next 20 years. In concert with efforts to reduce or reverse subsidence, selected areas or islands would be managed as waterfowl habitat. Besides increasing waterfowl resources, efforts to sustain waterfowl and their habitat will help offset some of the effects of converting agricultural or seasonal wetlands to tidal action when such actions may reduce the value of an area to waterfowl such as white-fronted geese or mallard. Efforts should also be focused on improving waterfowl nesting success by improving nesting and brood habitat. Improving waterfowl populations will be done in a manner that reduces conflict with broader ecosystem restoration goals or with goals to recover endangered species. For example: Flooding of rice fields for waterfowl in late winter may require water needed by migratory salmon. Careful management of the amount and timing of those diversions and the manner in which the diversions occur (e.g. through screened diversions) can help reduce conflicts. Management of waterfowl areas will occur using management strategies developed for existing and new waterfowl areas that provide benefits to at-risk species.*

## SHOREBIRD GUILD (nc)

**POPULATION TARGET**: Improve populations and distribution of shorebirds birds (◆◆).

**PROGRAMMATIC ACTIONS:** Shorebirds and wading birds will indirectly benefit from restoration of wetlands and tidal and nontidal perennial aquatic habitat (ponds and lakes).

***RATIONALE:*** *Loss and degradation of wetland and aquatic habitats used by wintering and* *migrant shorebirds in the Central Valley is a factor limiting populations of these species. Large-scale restorations of these habitats will increase the available foraging habitat area to better accommodate existing populations and potential future expansions of shorebird populations.*

## WADING BIRD GUILD (nc)

**POPULATION TARGET**: Improve populations and distribution of wading birds (◆◆).

**PROGRAMMATIC ACTION**: Wading birds will indirectly benefit from restoration of wetlands, tidal and nontidal perennial aquatic habitat (ponds and lakes), and riparian habitat.

***RATIONALE:*** *Substantial loss and degradation of aquatic, wetland and riparian habitats used by wintering and resident wading birds in the Central Valley is a factor limiting populations of these species. Large-scale restorations of these habitats will increase the available foraging, roosting, and nesting habitat area to better accommodate existing populations and future potential expansions of wading bird populations.*

## NEOTROPICAL MIGRATORY BIRDS (nc)

**POPULATION TARGET:** Increase the abundance and distribution of neotropical migratory birds in the Central Valley (◆◆).

**PROGRAMMATIC ACTIONS:** The following types of general programmatic actions will assist in meeting the target for neotropical migratory birds:

- increase wetland, riparian, grassland, and agricultural habitats,
- improve watershed health,
- improve specific nesting habitats for individual species within their existing and restored habitats, and
- protect nesting habitats from predators and human disturbance.

***RATIONALE:*** *Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds.*

## WESTERN SPADEFOOT (m)

**POPULATION TARGET**: Identify and protect remaining spadefoot toad populations in the Bay-Delta watershed (◆).

**PROGRAMMATIC ACTION**: Conduct a thorough survey of spadefoot toad populations in the Bay-Delta watershed and take actions to protect remaining populations in counties bordering the Bay-Delta system.

***RATIONALE:*** *Spadefoot toad populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat in which they can burrow for over summering. These habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to* *local habitat conditions. Long-term survival of spadefoot toad populations depends on protected areas containing both breeding ponds and upland habitats.*

## BAY-DELTA FOODWEB ORGANISMS (nc)

**POPULATION TARGET**: Increase populations and distribution of important foodweb organisms in Delta channels and reduce competition with invasive non-native species (◆◆).

**PROGRAMMATIC ACTION**: Actions in the Sacramento-San Joaquin Delta Ecological Management Zone that will contribute to reaching the target for Bay-Delta aquatic foodweb organisms include improvements to ecological processes such as Central Valley streamflows, natural floodplain and flood processes, and Delta channel hydraulics; improving habitats such as tidal perennial aquatic habitat, Delta sloughs, and fresh emergent wetland habitat; and the reduction or elimination of the adverse effects of stressors such as water diversion, dredging and sediment disposal, invasive aquatic plants, invasive aquatic organisms, and contaminants.

***RATIONALE:*** *The population target is quite likely impossible to achieve because recent invading species, from the Asiatic clam to various crustacean zooplankters, will continue to play major ecological roles in the system, to the detriment of native organisms. However, at the very least it is possible to stop further introductions of non-native species which have the potential to further change the system unpredictably. This target is also a call to develop a thorough understanding of the planktonic portion of the Bay-Delta system to predict and understand the impacts of large-scale ecosystem alteration projects on the plankton.*

***Strategic Plan Harvested Species***

## WHITE STURGEON (nc)

**POPULATION TARGET:** Meet Native Fish Recovery Plan goals (U.S. Fish and Wildlife Service 1996), which include 100,000 white sturgeon and 2,000 green sturgeon greater than 100 centimeters long as measured in the DFG mark-recapture program (◆◆).

**PROGRAMMATIC ACTIONS:** Sturgeon restoration will come indirectly from increasing March to May Delta inflow and outflow, improving Delta channel hydraulics and the Delta aquatic foodweb, and reducing stressors, including effects of water diversions and contaminants.

***RATIONALE:*** *White sturgeon represent an unusual situation: a success story in the management of the fishery for a native species. Numbers of sturgeon today are probably nearly as high as they were in the nineteenth century before they were devastated by commercial fisheries. The longevity and high fecundity of the sturgeon, combined with good management practices of the California Department of Fish and Game, have allowed it to sustain a substantial fishery since the 1950s, without a major decline in numbers. Numbers of white sturgeon could presumably be increased if the San Joaquin River once again contained suitable habitat for spawning and rearing.*

## STRIPED BASS (nc)

**POPULATION TARGET**: Restore the adult population (greater than 18 inches total length) to 1.1 million fish within the next 10 years. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities (◆◆).

**PROGRAMMATIC ACTION:** Restoring striped bass will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; increasing shallow water, riparian, and wetland habitats in the Delta; and reducing stressors including effects of water diversions and contaminants. To meet target population level may require, at least in the short-term, supplementing young production through artificial rearing and stocking of young striped bass salvaged at south Delta fish facilities or raised in hatcheries.

**TARGET:** Maintain an adult population of 3.0 million adult fish (◆).

**PROGRAMMATIC ACTION:** Achieving the target population of 3.0 million adult striped bass will require restoration actions in the San Joaquin River, Sacramento-San Joaquin Delta, and Sacramento River Ecological Management Zones. Within the Sacramento River Ecological Management Zone, proposed programmatic actions for Central Valley stream temperatures, Central Valley stream flow, and water diversions will contribute to restoration of striped bass.

***RATIONALE:*** *The striped bass is a non-native species that is a favorite sport fish in the estuary. It is also the most abundant and voracious piscivorus fish in the system and it has the potential to limit the recovery of native species, such as chinook salmon and steelhead. Therefore, the management for striped bass must juggle the objectives of providing opportunities for harvest while not jeopardizing recovery of native species. An appropriate policy may be to allow striped bass to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially artificial propagation. Artificially reared bass have the potential to depress not only native fish populations but also populations of wild striped bass, because larger juveniles (of hatchery origin) may prey on smaller juveniles (of wild origin). If increases in bass numbers appear to adversely affect recovery of native species, additional management measures may be required to keep bass numbers below the level that pose a threat to native species.*

## AMERICAN SHAD (nc)

**POPULATION TARGET:** The target for American shad is to maintain production of young as measured in the fall midwater trawl survey and targets of the Anadromous Fish Restoration Program (US Fish and Wildlife Service 1997, in preparation). Specifically, the index of young American shad production should increase, especially in dry water years (◆).

**PROGRAMMATIC ACTION:** Restoring American shad populations will come indirectly from increasing March to May Delta inflow and outflow, improving Delta channel hydraulics, improving the Delta aquatic foodweb, and reducing stressors, including the effects of water diversions and contaminants.

**TARGET:** Maintain a 25-year average index of abundance equal to the 1967 through 1976 fall midwater trawl index (◆).

**PROGRAMMATIC ACTION:** Actions in the Sacramento River Ecological Management Zone have been designed specifically to restore American shad and its habitat. This species will directly benefit from actions in this zone to increase the areal extent and distribution of riparian and riverine aquatic habitats (See implementation objective, targets, and programmatic actions that address riparian and riverine aquatic habitat.) Additional programmatic actions that will contribute to restoration of American shad are proposed for the Feather River/Sutter Basin, American River Basin, San Joaquin River, and Sacramento-San Joaquin Delta Ecological Management Zones.

***RATIONALE:*** *The American shad is a non-native species that is an important sport fish in the estuary and its spawning streams, although less seems to be known about its life history in the* *estuary than any other major game fish. It is a common planktivore and occasional piscivore in the system and it may have the potential to limit the recovery of native species, such as chinook salmon. Therefore, the management for American shad must juggle the objectives of providing opportunities for harvest without jeopardizing recovery of native species. An appropriate policy may be to allow American shad to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially flow releases specifically to favor shad reproduction. If increases in shad numbers appear to adversely affect recovery of native species, additional management measures may be required to keep shad numbers below the level that pose a threat to native species.*

## NON-NATIVE WARMWATER GAMEFISH (nc)

**POPULATION TARGET**: Increase our knowledge about warmwater sport fishes in the Delta, Suisun Marsh, riverine backwaters, and elsewhere to find out their interactions with native fishes, limiting factors, and their contaminant loads (for both fish and human health) (◆◆).

**PROGRAMMATIC ACTION**: Conduct studies to find out how major CALFED actions are likely to affect the warmwater fish and fisheries and how the fishes affect the recovery of native at-risk species. In particular, the potential of the non-native fishes to use and dominate newly created warmwater habitat will have been thoroughly investigated.

***RATIONALE:*** *White catfish, channel catfish, brown and black bullhead, largemouth bass, and various sunfishes are among the most common fishes caught in the sport fishery in the Delta, Suisun Marsh, riverine backwaters, reservoirs, and other lowland waters. Although this fishery is poorly documented, it is probably the largest sport fishery in central California in terms of people engaged in it and in terms of numbers of fish caught. There is no sign of overexploitation of the fishes, although some (e.g., white catfish) have remarkably slow growth rates, indicating vulnerability to overexploitation. The fishes and the fishers are always going to be part of the lowland environment and deserve support of the management agencies. However, habitat improvements that favor native fishes, especially improvements that increase flows or decrease summer temperatures, may not favor these game fishes. The effects of the various CALFED actions on these fish and fisheries need to be understood, as do the interactions among the non-native fishes and the native fish CALFED is trying to protect.*

## PACIFIC HERRING (nc)

**POPULATION TARGET:** Increase abundance of marine/estuarine fish and large invertebrates, particularly in dry years (◆).

**PROGRAMMATIC ACTIONS:** General programmatic actions that will contribute to the target include improving winter/spring Delta outflow, restoring tidal wetland habitat, improving the aquatic foodweb, reducing losses of larvae and juvenile marine/estuarine fishes at water diversions in the Bay and Delta, limiting the introductions of non-native species, and reducing the input of toxic substances into Central Valley waterways.

***RATIONALE:*** *Pacific herring support the most valuable commercial fishery in San Francisco Bay. This seasonal, limited-entry fishery focuses on spawning fish, for the fish themselves, their roe, and kazunoko kombu (herring eggs on eel grass). It seems to be an example of successful fishery management because it has been able to sustain itself through a series of years with highly variable ocean and bay conditions. An important connection to the ERP is that highest survival of herring embryos (which are attached to eel grass and other substrates) occurs during years of high outflow during the spawning period; the developing fish seem to require a relatively low-salinity environment. There is also some indication that populations have been lower since* *the invasion of the Asiatic clam into the estuary, with the subsequent reduction in planktonic food organisms. Given the frequent collapse of commercial fisheries (including those for herring) in the modern world, it is best to manage this fishery very cautiously to make sure it can continue indefinitely.*

## GRASS SHRIMP (nc)

**POPULATION TARGET**: Maintain grass shrimp populations at present levels as a minimum to support the existing commercial fisheries. Determine factors regulating their populations in order to discover if the fisheries conflict with other ecosystem restoration objectives (◆◆).

**PROGRAMMATIC ACTION**: Conduct an investigation of the ecological role and requirements of the shrimp species and the effects of the fishery to find out if any special management for either is needed.

***RATIONALE**: Grass shrimp are a mixture of native and introduced species that support a small commercial fishery in San Francisco Bay, largely for bait. The relative abundance of the various species as well as their total abundance appears to be tied in part to outflow patterns. It is likely that these abundant shrimp are important in Bay-Delta food webs leading to many other species of interest. The role of these shrimp in the Bay-Delta system and the effects of the fishery on that role need to be investigated.*

## SIGNAL CRAYFISH (nc)

**POPULATION TARGET**: Maintain signal crayfish populations at present levels, in order to support the existing fisheries (◆◆).

**PROGRAMMATIC ACTION**: Conduct an investigation of the ecological requirements of the crayfish and the effects of the fishery to find out if any special management for either is needed.

***RATIONALE**: The signal crayfish is an introduced species that supports a small commercial fishery, as well as a recreational fishery, in the Delta. It has been established in the Delta for nearly a century and appears to be integrated into the Bay-Delta system, appearing as a major food item for otters and some fish. The signal crayfish has fairly high water quality requirements so its populations will presumably increase as water quality in the freshwater portions of the Delta improves. Its role in the ecosystem and the effects of the fishery on that role need to be investigated.*

## UPLAND GAME (nc)

**POPULATION TARGET**: Increase the populations and distribution of upland game (◆◆).

**PROGRAMMATIC ACTION**: Upland game will indirectly benefit from restoration of wetlands, perennial grasslands, riparian, and improved management of agricultural lands in the Delta.

**PROGRAMMATIC ACTION**: Provide high ground adjacent to current and expanded habitat with cover for protection from floods. Existing flood control levees adjacent to agricultural lands could be utilized for this escape habitat in this area to provide sufficient vegetative growth of grasses, forbs, and shrubs to lower predation pressure during these times and when adjacent lands are fallow.

***RATIONALE**: Upland game are supported by diverse agricultural and upland habitats. The key to maintaining these species is by maintaining the habitats upon which they depend.*

**Table 2. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups.**

| Species and Species Group Visions | Ecological Management Zone[1] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Delta Smelt | ● | ● | | | | | | | | | | | | |
| Longfin Smelt | ● | ● | | | | | | | | | | ● | | |
| Green Sturgeon | ● | ● | ● | | | | | ● | | | | | | |
| Sacramento Splittail | ● | ● | ● | | | | | ● | ● | | ● | ● | | |
| Winter-run Chinook Salmon | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | |
| Spring-run Chinook Salmon | ● | ● | ● | | | | | | | | ● | ● | ● | |
| Fall-run Chinook Salmon (including late-fall-run) | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | |
| Steelhead Trout | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | |
| Lamprey | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | |
| California Clapper Rail | | ● | | | | | | | | | | | | |
| California Black Rail | ● | ● | | | | | | | | | | | | |
| Swainson's Hawk | ● | ● | | | | | | | ● | ● | ● | ● | ● | |
| Suisun Song Sparrow | | ● | | | | | | | | | | | | |
| Alameda Song Sparrow | | ● | | | | | | | | | | | | |
| Salt Marsh Harvest Mouse | | ● | | | | | | | | | | | | |
| Suisun Ornate Shrew | | ● | | | | | | | | | | | | |

**Table 2. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups** (continued).

| Species and Species Group Visions | Ecological Management Zone[1] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| San Pablo California Vole | | ● | | | | | | | | | | | | |
| Special-status Plant Species | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Valley Elderberry Longhorn Beetle | ● | ● | ● | ● | ● | | | | | | | | | |
| Riparian Brush Rabbit | ● | | | | | | | | | | | | ● | |
| San Joaquin Valley Woodrat | ● | | | | | | | | | | | | ● | |
| Sacramento Perch | ● | ● | ● | ● | | | | | | | ● | ● | ● | ● |
| Greater Sandhill Crane | ● | | | | | | | | | | | | | |
| Western Yellow-Billed Cuckoo | ● | | ● | | | | | | | | | ● | ● | |
| Bank Swallow | | | | ● | | | | | | | | | | |
| Western Least Bittern | ● | ● | ● | ● | | | | | | | | ● | | |
| Least Bell's Vireo | ● | ● | ● | ● | | | | | | | | ● | | |
| California Yellow Warbler | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Little Willow Flycatcher | | | | ● | | | | | ● | | ● | ● | ● | |
| Giant Garter Snake | ● | ● | | | | ● | ● | | ● | | ● | ● | ● | |
| California Tiger Salamander | ● | | | | | | | | | | | | | |

**Table 2.** **Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups** (continued).

| **Species and Species Group Visions** | **Ecological Management Zone[1]** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |
| Western Spadefoot | ● | | | | | | | | | | | | | |
| California Red-Legged Frog | ● | ● | | | | ● | ● | | ● | | ● | ● | ● | ● |
| Native Anuran Amphibians | ● | ● | | | | ● | ● | | ● | | ● | ● | ● | ● |
| Western Pond Turtle | ● | ● | | | | ● | ● | | ● | | ● | ● | ● | |
| Delta Green Ground Beetle | ● | ● | | | | | | | | | | | | |
| Lange's Metalmark butterfly | ● | ● | | | | | | | | | | | | |
| California Freshwater Shrimp | | ● | | | | | | | | | | | | |
| Native Resident Fish Species | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Bay-Delta Foodweb Organisms | ● | ● | | | | | | | | | | | | |
| Shorebird and Wading Bird Guild | ● | ● | | | | | | | | | | | ● | |
| Waterfowl | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● |
| Neotropical Migratory Bird Guild | ● | ● | ● | ● | | | | | | ● | ● | ● | ● | ● |
| Upland Game | ● | | ● | ● | | | | | | ● | ● | ● | ● | ● |

**Table 2.** **Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups** (continued).

| Species and Species Group Visions | Ecological Management Zone[1] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Plant Community Groups | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Striped Bass | ● | ● | ● | | | | | ● | ● | | | ● | | |
| White Sturgeon | ● | ● | ● | | | | | ● | | | | ● | | |
| American Shad | ● | ● | ● | | | | | ● | ● | | | ● | | |
| Non-native Warmwater Gamefish | ● | ● | ● | | | | | | | ● | ● | ● | ● | ● |
| Pacific Herring | | ● | | | | | | | | | | | | |
| Signal Crayfish | ● | | ● | | | | | | | | | | | |
| Grass Shrimp | | ● | | | | | | | | | | | | |

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

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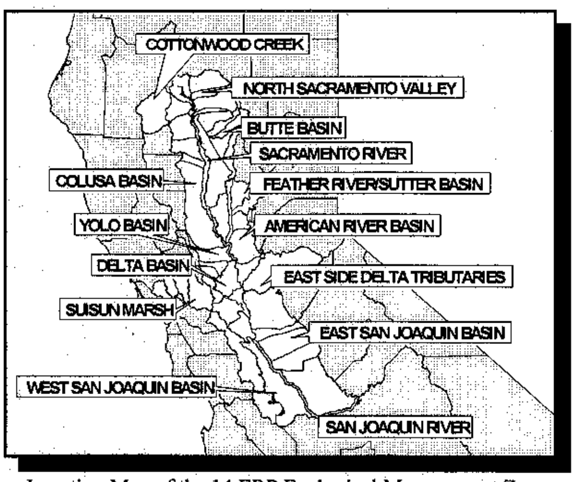
# ◆ Ecological Management Zones

## Introduction

The following section provides the ecological management zone visions for the 14 areas that compose the ERPP study area. These include the following ecological management zones:

- Sacramento-San Joaquin Delta
- Suisun Marsh/North San Francisco Bay
- Sacramento River
- North Sacramento Valley
- Cottonwood Creek
- Colusa Basin
- Butte Basin
- Feather River/Sutter Basin
- American River Basin
- Yolo Basin
- Eastside Delta Tributaries
- San Joaquin River
- East San Joaquin
- West San Joaquin.




Location Map of the 14 ERP Ecological Management Zones

## Distinguishing Characteristics

Understanding the structure, function and organization of ecosystems is necessary for planning and implementing environmental restoration, rehabilitation and protection projects. Such understanding enables managers to assess, during planning phases of a program, the degree to which prospective restoration sites diverge from a "healthy" or "natural" condition, as well as to evaluate, after actions have been undertaken, project progress and effectiveness. In a management context, perhaps the most practical means of summarizing the most relevant existing information on ecosystems is to develop, over an appropriate hierarchy of spatial and ecological scales, a list of key system attributes - those fundamental natural ecological characteristics that together define and distinguish these systems, their status, and/or their interrelationships. Such lists of attributes may serve as a convenient and necessary "check list" of environmental factors that might be addressed in an ecological restoration/rehabilitation context. At sites for which comprehensive restoration is the goal, a full suite of applicable attributes would presumably be addressed. More commonly, at sites where partial restoration (rehabilitation) is the goal, actions and efforts would be focused upon an appropriate subset of attributes.

Some individual system attributes - such as water temperature - may be evaluated directly. Others, such as "habitat continuity," are more nebulous, and must be evaluated by developing appropriate "indicators" - measurable parameters that provide a means to objectively (preferably quantitatively) evaluate individual attributes that in themselves are not readily measured. The term indicators is also used in a broader context to refer to a *subset* of system attributes (or their measurable parameters) that are derived and used *as a group* to provide a convenient way to evaluate *overall* system status. Thus, the term "indicator" is commonly used in two somewhat different ecosystem management/restoration contexts, representing two differing scales of resolution: that of *individual* attributes, or alternately, that of *groups* of attributes. In either case, "indicators" are simply a convenient way of measuring or evaluating that which is of primary concern - system attributes. An additional, and most useful tool in understanding and describing fundamental characteristics of complex systems is the use of conceptual models that integrate and diagrammatically represent the three basic *kinds* of system components: elements (attributes), their states, and the relationships that affect attribute states.

## ECOSYSTEM TYPOLOGY

The ERPP study area is divided into four ecological zones, based on similarities and differences in their respective attributes. (Refer to the Key Ecological Attributes of the San Francisco Bay-Delta Watershed section of ERPP Volume I for additional details regarding the ecosystem typology.) The ecological zone designations follow:

- Upland River-Floodplain Ecological Zone
- Alluvial River-Floodplain Ecological Zone
- Delta Ecological Zone
- Greater San Francisco Bay Ecological Zone

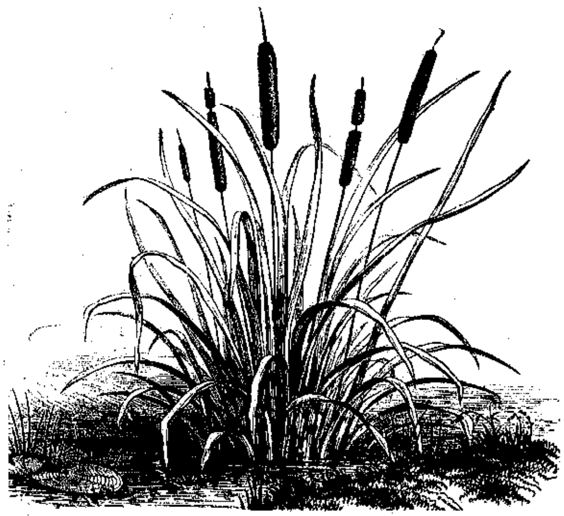
Each of the 14 ecological management zone is contained within one or more ecological zones. The following tables display the distribution of ecological managements zones within each ecological zone.

**Table 3. Distribution of Ecological Management Zones within the Ecological Zone Typology.**

| Ecological Management Zone | Ecological Zone | | | |
|---|---|---|---|---|
| | Upland River-Floodplain | Alluvial River-Floodplain | Delta | Greater San Francisco Bay |
| Sacramento San Joaquin Delta | | | ● | |
| Suisun Marsh/North San Francisco Bay | ○ | | | ● |
| Sacramento River | | ● | | |
| North Sacramento Valley | ● | ○ | | |
| Cottonwood Creek | ● | | | |
| Colusa Basin | ● | ● | | |
| Butte Basin | ● | ○ | | |
| Feather River/Sutter Basin | ○ | ● | | |
| American River Basin | ● | ● | | |
| Yolo Basin | ● | ● | | |
| Eastside Delta Tributaries | ○ | ● | | |
| San Joaquin River | | ● | | |
| East San Joaquin | | ● | | |
| West San Joaquin | ● | | | |

● Denotes primary ecological zone, ○ Denotes secondary or less prevalent ecological zone.

# ◆ Sacramento-San Joaquin Delta Ecological Management Zone



## Introduction

The Sacramento-San Joaquin River Delta (Delta) is the tidal confluence of the Sacramento and San Joaquin rivers. Between the upper extent of tidewater (i.e., near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and the confluence of the two rivers near Collinsville is a maze of tidal channels and sloughs known as the Delta. Once a vast maze of interconnected wetlands, ponds, sloughs, channels, marshes, and extensive riparian strips it is now islands of reclaimed farmland protected from flooding by hundreds of miles of levees. Remnants of the tule marshes are found on small "channel" islands or shorelines of remaining sloughs and channels.

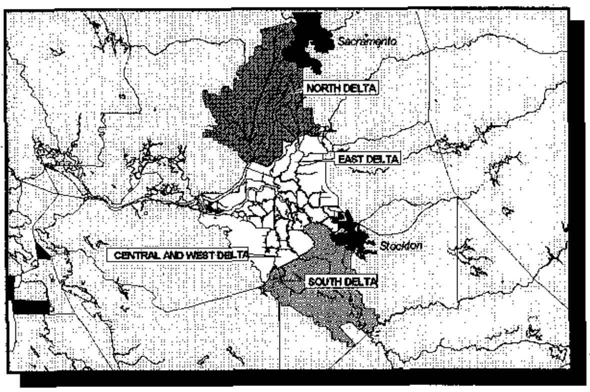
The Delta is home to many species of native and non-native fish, waterfowl, shorebirds, and wildlife. All anadromous fish of the Central Valley either migrate through the Delta or spawn in, rear in, or are dependent on the Delta for some critical part of their life cycle. Many of the Pacific Flyway's waterfowl and shorebirds pass through or winter in the Delta. Many migratory song birds and raptors migrate through the Delta or depend on it for nesting or wintering habitat. Despite many changes, the Delta remains a productive nursery grounds and migratory route for many species. Four runs of chinook salmon, steelhead, green sturgeon, white sturgeon, lamprey, striped bass, and American shad migrate through the Delta on their journey between the Pacific Ocean and Central Valley spawning rivers. Native resident fish including delta smelt and splittail spend most of their lives within the Delta. Considerable areas of waterfowl and wildlife habitat occur along the channels and sloughs and within the leveed agricultural lands.

The Delta also supports many plants with restricted distribution and some important plant communities. Special status plant species include Mason's lilaeopsis, rose-mallow (hibiscus), eel-grass pondweed, Delta tule pea, and Delta mudwort. Important plant groups or communities include pondweed with floating or submerged leaves, bulrush series, cattail series, common reed series, vernal pool communities, black willow series, narrowleaf willow series, white alder series, buttonbush series, Mexican elderberry series, and valley oak series.

Ecological factors having the greatest influence on Delta fish and wildlife include freshwater inflow from rivers, water quality, water temperature, channel configuration and hydraulics, wetlands, riparian vegetation, and diversity of aquatic habitat. Stressors include water diversions, channelization, levee maintenance, flood protection, placement of rock for shoreline protection, poor water quality, legal and illegal harvest, wave and wake erosion, agricultural practices, conversions of agricultural land to vineyards, urban development and habitat loss, pollution, and introductions of non-native plant and animal species.

# Description of the Management Zone

The Sacramento-San Joaquin Delta Ecological Management Zone is defined by the legal boundary of the Sacramento-San Joaquin River Delta. It is divided into four regional Ecological Management Units: North Delta, East Delta, South Delta, and Central and West Delta Ecological Management Units.




Location Map of the Sacramento-San Joaquin Delta Ecological Management Zone and Units.

The Delta is the easternmost portion of the estuary, and today is clearly delineated by a legal boundary that includes the areas that historically were intertidal, along with supratidal portions of the floodplains of the Sacramento and San Joaquin rivers. Today's legal Delta extends between the upper extent of the tidewater (near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and Chipps Island to the west, and encompasses the lower portions of the Sacramento and San Joaquin river-floodplain systems as well as those of some lesser tributaries (e.g., Mokelumne River, Calaveras River).

The Sacramento-San Joaquin Delta Ecological Management Zone is characterized by a mosaic of habitats that support the system's fish, wildlife, and plant resources. Instream and surrounding topographic features influence ecological processes and functions and are major determinants of aquatic community potential. Both the quality and quantity of available habitat affect the structure and composition of the Delta's biological communities. Currently, much of the remaining natural habitats consists of small, scattered, and degraded parcels. Other, more common wildlife habitats on agricultural lands are at risk of loss because of levee failures. Important aquatic habitats are severely limited by levees and flood control systems.

Important aquatic habitats in the Delta include shaded riverine aquatic (SRA) habitat; vegetated and nonvegetated shallow shoal areas; open-ended sloughs, both large and small; and small dead-end sloughs. The large, open river channels of the Sacramento and San Joaquin rivers in the central and western Delta are more like the tidal embayments of Suisun Bay to the west of the Delta. Areas with SRA habitat are fragmented and subject to excessive erosion from wind- and boat-generated waves. Shallow shoal areas are small and fragmented and are subject to excessive water velocities and periodic dredging that degrade or scour them.

In many areas, agricultural lands have become surrogate habitat for wildlife, partially replacing native habitats. For example, natural wetlands have been replaced by rice fields as habitat for waterfowl and natural grasses have been replaced by agricultural grains, corn, and alfalfa which provide food for geese and cranes. Agricultural lands have important benefits for wildlife in the Delta, but are not a substitute for natural habitat.

Remaining channels and sloughs have been modified to become water conveyance "facilities" and flood control features. These modifications resulted in elevated water velocities and loss of structural diversity. The few remaining small dead-end sloughs have lost their SRA habitat, are choked with water hyacinth, and have poor water quality from agricultural and dairy runoff. Reclamation of Delta islands has cut off miles of dead-end sloughs that once drained extensive tidal wetlands and has significantly reduced the amount of land-water interface.

Geographic Information System (GIS) program analysis of 1906 U.S. Geological Survey maps by the Department of Fish and Game (Bay-Delta and Special Water Projects Division) provided estimates of the historical wetted perimeter in Delta sloughs and channels and tidal wetlands. *[Note: Wetted perimeter is the linear measurement of shoreline. Total wetted perimeter is compared to the total acreages of related dry land within a defined area to calculate a ratio of wetted perimeter to land acreage. Higher ratios of wetted perimeter indicate a more extensive mosaic of habitats (e.g., backwaters, sloughs, floodplains, marshes, and islands).]* The 1906 maps were the earliest available, and even then many Delta levees had already been constructed. These perimeter calculations were compared to similar data from GIS mapping by Pacific Meridian for the California Department of Fish and Game (DFG) using 1993 satellite imagery. That comparison indicated that there have been wetted perimeter reductions in three of the four Delta Ecological Management Units since 1906. Wetted perimeter reductions ranged from 25.2% to 44.7%.

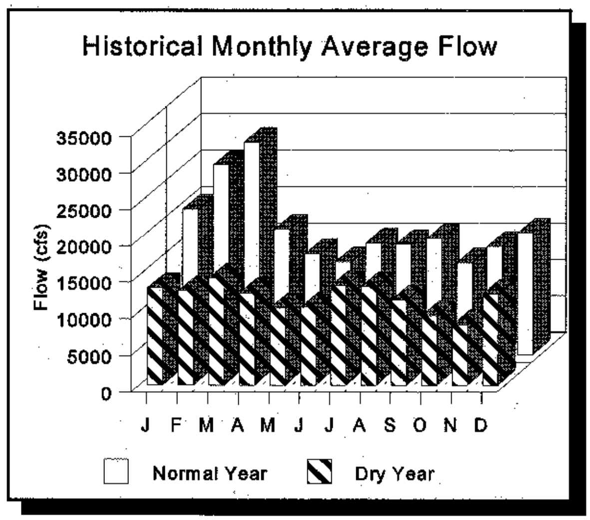
**Change in Ratio of Wetted Perimeter 1906 to 1993**
(Ratio of water to land acreage)

| Ecological Unit | 1906 | 1993 | Percentage of change |
|---|---|---|---|
| North Delta | 3.4 | 4.5 | +32.3% |
| East Delta | 10.5 | 7.1 | -32.4% |

Central Valley water supply and hydroelectric projects have had a large effect on the freshwater flow through the Delta. Spring flows that, before water projects, averaged 20,000 to 40,000 cubic feet per second (cfs) in dry years and 40,000 to 60,000 cfs in normal years have, in recent decades, averaged only 6,000 to 10,000 cfs in dry years and 15,000 to 30,000 cfs in normal years. In the driest years, spring flows were once 8,000 to 14,000 cfs, while under present conditions they average only 2,500 to 3,000 cfs.

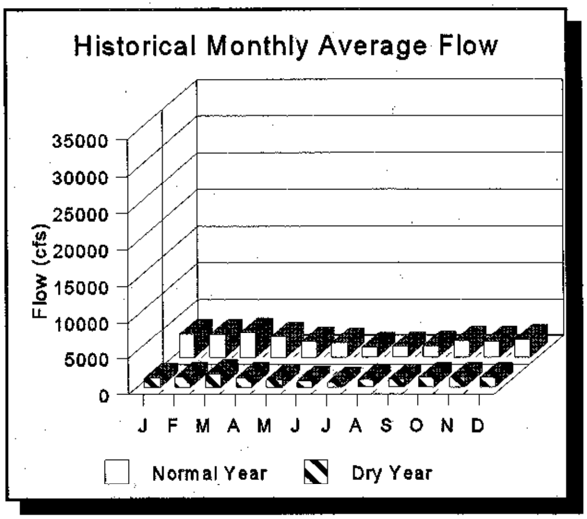
In dry and normal years, summer outflow from the Delta has remained in the 4,000 to 8,000 cfs range because water is released from reservoirs to keep salt-water from entering the Delta. Summer inflows that were only 4,000 to 8,000 cfs in dry and normal years now exceed 10,000 cfs as water is released from reservoirs to satisfy demands for water diversions.

Winter flows have fallen from the 15,000- to 60,000-cfs range to the 7,000- to 35,000-cfs range because much runoff from winter rains is now stored in foothill reservoirs. Flows in years with the highest rainfall are relatively unchanged, although short-term peaks are attenuated by flood control storage in the larger foothill reservoirs.



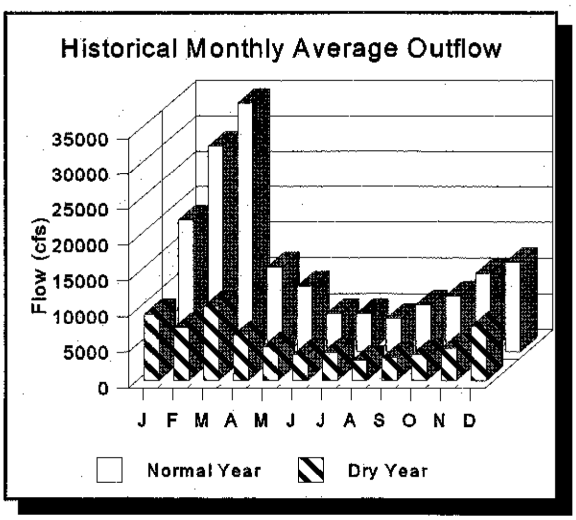

Historical Delta Inflow from Sacramento River measured at Freeport, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Much of the Delta outflow is made up of Sacramento River flow entering the Delta near Sacramento. Although inflows through the Sacramento River channel reach 60,000 to 80,000 cfs in winter and spring of wet years, inflows are generally less than 30,000 cfs. In the driest years, inflows range from 5,000 to 9,000 cfs through the entire year, while in dry years they range from 8,000 to 15,000 cfs. In wet years, floodflows that average up to 130,000 cfs per month enter the Delta from the Yolo Bypass through Cache Slough.




Historical Delta Inflow from San Joaquin River Flow measured at Vernalis, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

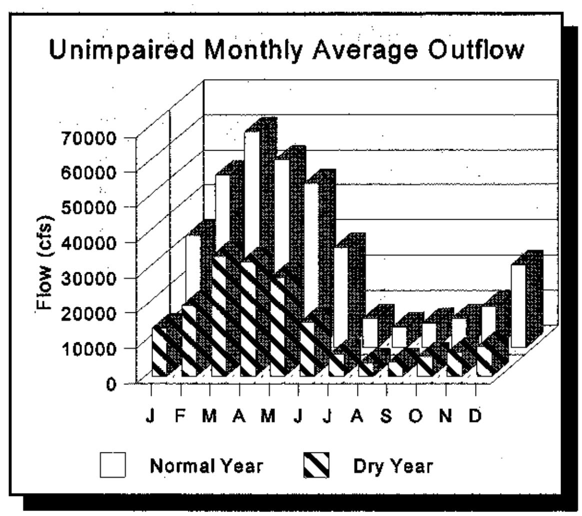
Most of the remaining inflow to the Delta comes from the Mokelumne River and the San Joaquin River. The Mokelumne River contributes only 100 to 300 cfs in dry and normal years. The San Joaquin River flows make up most of the remainder with average monthly flows of 500 to 1,500 cfs in dry years, 1,500 to 3,500 cfs in normal years, and up to 20,000 to 40,000 cfs in wet years.




Historical Delta Outflow for 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Water diversions from the Delta may reduce outflows by as much as 14,000 cfs. Of that total, small Delta agriculture diversions combine to divert up to approximately 3,000 cfs during peak irrigation seasons. State Water Project (SWP) and Central Valley Project (CVP) pumping plants in the southern Delta can divert up to 11,000 cfs.
Natural floodplains and flood processes are the periodic flooding of the floodplain during peak flow events that would typically occur in late winter and spring of all but the driest years. Land reclamation and levee construction have eliminated much of the natural Delta floodplain, forcing waters to rapidly exit the Delta through confined channels. Only the Yolo Bypass and adjoining leveed islands are periodically flooded to help carry large flows coming down the Sacramento River.

Reductions in spring freshwater flow into the Delta and the loss of riparian vegetative cover




Unimpaired Delta Outflow Estimated for Period 1972-1992 (Dry year is the 20th percentile; normal year is the 50th percentile or median year.)

have led to slightly increased water temperatures in the Delta. Agricultural and other discharges into the Delta including power plant cooling water have also increased Delta water temperatures. Maintaining water temperatures in the Delta during the transitions in spring and fall is necessary to meet the needs of migrating salmon and steelhead passing through the Delta. Reduced March to May inflows and loss of riparian (waterside) and SRA habitats in the Delta have also contributed to higher water temperatures in the Delta.

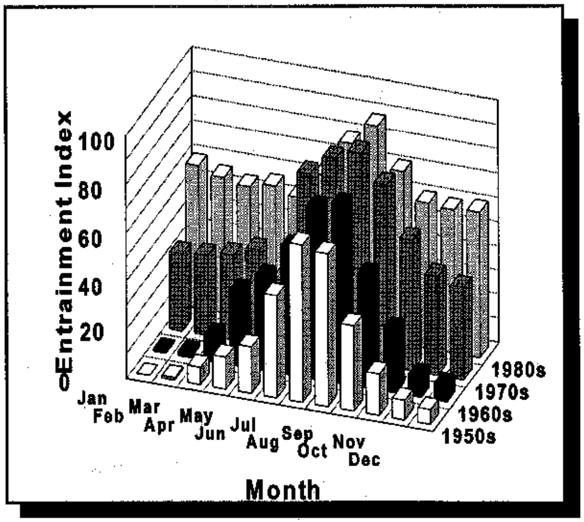
Changes in Delta channel hydraulics (water flows) began in the mid-19th century with land reclamation that restricted flows to narrow channels of levees. Floodflows that once spilled into a vast floodplain are now confined to narrow channels. These same channels later became conduits for carrying water to water-export facilities in the central and south Delta. In 1951, the CVP began to transport water from the south Delta at Tracy to the Delta-Mendota Canal. That same year, operation of the Delta Cross Channel (DCC) began to allow Sacramento River water to flow through interior Delta channels to the south Delta export facilities at Tracy. South Delta export facilities were increased with the addition of the SWP pumping plant at Byron in the late 1960s. In 1968, the SWP began to transport Delta water through the California Aqueduct to southern California.

Existing hydraulic conditions inhibit the function of Delta channels as migration corridors and rearing habitat for salmon and other anadromous fish, including steelhead, striped bass, American shad, white sturgeon, and green sturgeon. Native resident fish such as delta smelt and splittail also depend on natural hydraulic processes, as hydraulic conditions determine physical habitat characteristics and foodweb (all of the food chains) production (i.e., by controlling the residence time of water in Delta channels). Natural hydraulic conditions benefit other resident freshwater and estuarine fish, including longfin smelt, tule perch, threadfin shad, white catfish, largemouth bass, and starry flounder. Low residence time in Delta channels and sloughs decreases biological productivity and habitat value.

**Species-Habitat Associations**

| **Species** | ***Habitats*** |
|---|---|
| Swainson's hawk | *Riparian/Agricultural* |
| Clapper rail | *Tidal emergent wetland* |
| Black rail | *Tidal Emergent wetland* |
| Sandhill crane | *Seasonal aquatic and wetland, agricultural, and grassland* |
| Riparian brush rabbit | *Contiguous riparian woodland* |
| Shore and wading birds | *Aquatic and wetland, seasonal aquatic, and agricultural* |
| Upland game birds | *Agricultural, riparian, and upland* |
| Waterfowl | *Tidal perennial aquatic, seasonal aquatic, riparian, agricultural, and wetland* |
| Neotropical migratory birds | *Riparian, grassland, agricultural land* |
| Delta smelt | *Shallow water, sloughs, bays* |
| Splittail | *Marsh, floodplain, sloughs* |
| Striped bass | *Shallow water, sloughs* |

Channel hydraulics once were relatively unaltered in the Delta. In November through March, an important period for aquatic species, hydraulic changes were insignificant in the 1950s and 1960s, as measured using an indicator of hydraulic conditions provided by output from a particle transport model (DeltaMOVE). However, by the 1980s, there had been a dramatic increase in unhealthy channel hydraulic conditions in locations such as the Central and West Delta.



Historic Calculated Entrainment Indices of the Central and West Delta Ecological Management Unit.

Aquatic foodweb productivity in the Delta has declined over the past several decades and is the subject of ongoing focused research activities. The decline was caused by changes in freshwater inflow, Delta channel hydraulics (i.e., water residence time), water diversions, water quality, and the species composition of aquatic organism communities. Foodweb productivity, beginning at the primary production (i.e., plant cell production) level, is essential to provide enough food to maintain populations of important fish. Primary productivity in the Delta depends on spring flow events in dry and normal years. Spring flows deliver essential nutrients, increase residence time in channels and sloughs, and increase shallow water and wetland habitat.

The loss of tidal marshes (historic tule marshes) to agricultural conversion probably constituted one of the greatest causes of loss of productivity and a change in the nature of the aquatic foodweb (i.e., a change from a detritus-based food web characteristic of marshes to a more phytoplankton-based food web). Along with the loss of tidal marshes in the Delta to land reclamation came the loss of shallow-water aquatic habitats (e.g., small sloughs, ponds). Many native resident and anadromous fish and estuarine invertebrates depend on these habitats. Shallow-water habitats around the Delta provide spawning and rearing habitats for many native resident Delta fishes. They also provide important rearing and migratory habitats for many Central Valley chinook salmon and steelhead. Tidal perennial aquatic habitat benefits native waterfowl, wading and shorebirds, and wildlife, as well as native plants that depend on such habitats.

**Acres of Tidal Fresh Emergent Wetland (Marsh)**

| Ecological Management Unit | 1906 | 1993 | Percentage of change |
|---|---|---|---|
| North Delta | 53,660 | 4,640 | -91.3 |
| East Delta | 7,600 | 1,270 | -83.3 |
| South Delta | 470 | 650 | +38.3 |
| Central and West Delta | 37,170 | 5,040 | -86.4 |

Lakes and ponds support simple invertebrate communities, riparian habitat, and wintering waterfowl. Examples of nontidal perennial aquatic habitats include the Stone Lakes in the North Delta Ecological Management Unit near Sacramento and the "blow out ponds," or ponds remaining after levee breaks on islands such as Venice Island and Webb Tract. Most ponds also support introduced species such as the bullfrog and largemouth bass, which reduce the value of these ponds to special-status species such as the red-legged frog. Introduced species also reduce the habitat's value as brood water for nesting waterfowl. Such habitats within the Delta also benefit waterfowl, as well as many plant and wildlife species, including many rare or declining special status species.

After more than 100 years of land reclamation activities in the Delta, many linear miles of natural sloughs have been lost. Sloughs are important spawning and rearing areas for many native Delta fish species, as well as waterfowl and wildlife. Of those natural sloughs that remain, most have been severely degraded by dredging, levee confinement, loss of riparian vegetation, high water flow, infestation of water hyacinth, and poor water quality (i.e., many receive agricultural drain water).

Shoals are simple underwater islands or shallows in otherwise deeper channels of the Delta. Channel islands and shoals provide valuable fish and wildlife habitat within the confined reaches of Delta channels. Only "tule islands" or "berm islands" contain some original native Delta habitats. These islands are found in Delta channels where the distance between levees is wide enough that past dredging activities left a remnant strip where soils were deposited at an elevation high enough to support tules and cattails. Such islands generally have shallow water and SRA habitats, as well as tidal marsh and riparian habitats. The number and acreage of channel islands have declined over the past several decades from dredging, wave and wake erosion, and levee maintenance.

Tidal marshes, once the most widespread habitat in the Delta, are now restricted to remnant patches. A GIS analysis of 1906 U.S. Geological Survey maps determined the extent of change in tidal wetland since 1906. Extensive losses of tidal wetland habitats in three of the four Delta Ecological Management Units have exceeded 87,000 acres from 1906 to 1993. These losses represent only a portion of the change that have taken place since reclamation began in the mid-nineteenth century. It has been estimated that circa 1850, about 310,000 acres of the Delta consisted of tidal wetlands in a mosaic dominated by emergent vegetation, and included smaller tidal marsh drainage channels and open-water lakes and ponds (Atwater and Belknap 1980).

Nearly two-thirds of the reclamation of the Sacramento-San Joaquin Delta Ecological Management Zone for farmland occurred before 1906. Thirty percent of the lands reclaimed before 1900 were in the North Delta and East Delta Ecological Management Units, 38% in the South Delta Ecological Management Unit, and only 2% in the Central and West Delta Ecological Management Unit. Most of the remaining tidal wetlands lack adjacent upland transition habitat and other attributes of fully functioning tidal wetlands. This was caused by upstream water development, in-Delta export facilities, adjacent levee maintenance practices, agricultural practices, and urban and industrial development.

Tidal wetlands provide important habitats for many species of plants, waterfowl, and wildlife. In addition, wetlands provide an important contribution of plant (dead material) and nutrient recycling to the aquatic foodweb of the Bay-Delta estuary, as well as important habitat to some species of fish and aquatic invertebrates.

Seasonal wetlands include vernal pools, wet meadows or pastures, and other seasonally wetted habitats such as managed duck clubs in the Delta floodplain. Most of this habitat is located on leveed lands or in floodplain bypasses such as the Yolo Bypass. Such habitats were once very abundant during the winter rainy season or after seasonal flooding of the Delta. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from directed overflow of flood waters to bypasses, or from flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and wildlife.

Upland habitats are found mainly on the outer edges of the Delta and consist primarily of grasslands and remnant oak woodland and oak savanna. Of these, perennial grasslands are an important transition habitat for many Delta wildlife species. They are also buffers to protect wetland and riparian habitats. Much of the grassland habitat adjacent to the Delta has been lost to agriculture (e.g., grain, vineyards, and orchards) and development (e.g., home construction, golf courses). Grasslands provide habitats for many Delta plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees, berms, berm islands, and in the interior of some Delta islands. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitats provide shaded riverine aquatic habitats on which many important fish and wildlife depend during some portion of the life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse, habitat structure with low diversity.

Riparian habitat is used by more terrestrial wildlife species than any other Delta habitat type. From about 1850 to the turn of the century most of the riparian forests in the Delta were decimated for fuelwood as a result of the gold rush, river navigation, and agricultural clearing. Remnant patches are found on levees, channel islands, and along the margins of the Delta. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many species of fish and wildlife.

Inland dune scrub habitat is found in the south and west portions of the Delta in areas where wind-blown sand is deposited along margins of the Delta. Inland dune habitat has unique native plant communities including two special-status species. Much of the dune habitat has been lost to industrial and urban development.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors. Nonflooded fields and pastures are also habitats for pheasant, quail, and dove. The Delta supports a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields that support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations.

The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Delta. One of the highest breeding densities of Swainson's hawks in the Central Valley is found on the eastern edges of the Delta, primarily along the upland margins in areas adjacent with pastures, alfalfa croplands, and grasslands. The present-day Delta is mostly farmland, occupying over 86% of the dry-land area. The wildlife habitat value of these lands depends on crop types and agricultural practices employed, including flooding and tillage regimes. The farmed "wetlands" of the Delta are important for wintering water birds, including shorebirds, geese, swans, ducks, and sandhill cranes, supporting 10% of all waterfowl wintering in the State. The value of agricultural lands to other migratory birds is much greater. For example, the Delta is extremely important for tundra swans and greater sandhill cranes. In average years, 70% to 85% of the tundra swans in the Pacific Flyway winter in the Central Valley; 90% of this use occurs in just eight counties with the Delta being a major use area.

Water diversions in the Delta divert up to 14,000 cfs of the freshwater inflow to the Delta. Though diversions vary seasonally, relatively high rates can occur in any month. Water diverted from the Delta is used throughout much of the central and southern portion of the State.

With many diversions unscreened or poorly screened great numbers of fish and aquatic invertebrates are entrained with the water. Lack of adequate screening and location of water diversions in sensitive areas of the Delta contribute to the loss of important fish and aquatic foodweb organisms.

Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat throughout the Delta. Habitat on levees and shorelines needs improvement to restore the variety of species and ecological functions needed for aquatic and wildlife resources of the Delta.

Dredging and disposal of dredge materials have contributed to the loss and degradation of important aquatic habitat and vegetated berm islands in the Delta.

Over the past several decades, the accidental introduction of many marine and estuarine organisms from the ballast waters of ships from the Far East has greatly changed the plankton and benthic (bottom and shore dwelling) invertebrates of the Delta with further effects up the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta. Other important routes for the introduction of invasive species include overland at border crossings, aquaculture operations, and commercial bait dealers.

The numbers of predatory fish have increased at certain locations in the Delta (e.g., Clifton Court Forebay, docks, piers, etc.) and losses of some resident and anadromous fish to predation may limit their recovery. Predators may reduce populations of important fish, including chinook salmon, steelhead, and delta smelt.

Large amounts of toxins continue to enter the Delta from municipal, industrial, and agricultural discharges. The toxins have demonstrated in bioassay potential adverse effect on the health, survival, and reproduction of many important Delta fish and their foodweb organisms. Toxins in the tissues of the fish are also a human health risk to people who eat Delta fish. Continued reductions of toxins from discharges and from releases of toxins from the sediment (e.g., those disturbed by natural forces and dredging) are essential to the restoration program.

The legal and illegal harvest of fish may limit recovery of some populations in the Delta and its watersheds. Harvest of chinook salmon, steelhead, and sturgeon in the Delta may affect recovery of these populations. Harvest enforcement and management help sustain important fish populations from overharvest.

Boat traffic in the Delta contributes to the erosion of remaining shallow water, riparian, and wetland habitat along Delta channels and degrades water quality from fuel and oil spills. High boat speeds and traffic endanger remnant habitat and limit the success of habitat restoration.

The delta smelt population of the Bay-Delta estuary is a federally listed threatened species. It depends on the Delta for spawning and rearing habitat. It lives in fresh and brackish bays and sloughs of the Delta. Delta smelt decline is related to poor habitat conditions during periods of drought, but are also adversely affected by water diversions throughout the Delta. Delta smelt benefit from high freshwater inflow, particularly during the late winter and spring of dry years. Their recovery depends on adequate slough and shallow water habitat, reduced effects of water diversions, and increased productivity of the aquatic foodweb.

The longfin smelt populations of the Bay-Delta live within the brackish water and saltwater of northern San Francisco Bay and migrate upstream into the Delta to spawn. The decline in the longfin smelt population has coincided with a number of changes in the estuary including: low flows in late winter and spring, reduced freshwater flows through the Delta and into Suisun Bay, water diversion (particularly in drier years), and contaminants.

Like delta smelt, splittail are a native resident species of the Delta and Bay that depend on the Delta for spawning, rearing, and feeding. The Delta splittail population declined during droughts but has rebounded in recent years. Splittail depend primarily on shallow water habitats for spawning including shorelines, sloughs, and aquatic habitats associated with wetlands and seasonal floodplains (e.g., the Yolo Bypass in the north Delta). The splittail population will benefit from improved wetland and slough habitat, a more productive aquatic foodweb, reduced loss to predation, improved estuarine hydraulics, and higher late-winter and spring freshwater flows during dry years.

White sturgeon and green sturgeon populations in the Central Valley use the Delta for migrating, feeding, and as a nursery area. Populations appear to be stable. Do to lack of specific data for green sturgeon, however, the implication that this species is stable may be inaccurate. Sturgeon benefit from high late-winter and spring freshwater inflow, a productive aquatic foodweb, and slough habitats in the Delta. Legal and illegal harvest and losses to water diversions may be limiting their abundance.

Four runs of chinook salmon use Central Valley waterways. All four runs depend on the Delta during at least a portion of their life cycle. The Delta provides migratory and rearing habitat for salmon in all but the warmest summer months. Tidal perennial marsh habitat and adjoining sloughs and aquatic habitats in the Delta are important fry rearing habitats.

Many populations of chinook salmon have declined in recent decades. The decline was caused by a combination of ocean, river, and Delta factors. Reductions in freshwater flow through the Delta and increases in water diversions have led to declines in salmon populations. Improving late-winter and spring freshwater flows through the Delta and reducing losses to diversions are essential to the recovery of salmon. Chinook salmon also benefit from lower water temperatures in spring and fall, adequate aquatic habitats, and high foodweb productivity. Many juvenile chinook salmon are lost to water diversions and predators.

Steelhead usage of the delta-estuary is not well known and has not been studied. At the very least, they utilize the delta waterways for migration to and from the spawning and rearing tributaries. Generally, estuaries provide important - and on some small coastal tributaries, essential - rearing habitat for steelhead, but usage of the Sacramento-San Joaquin delta-estuary by steelhead for this purpose is unknown. Occurrences of juvenile steelhead are not uncommon at the CVP and SWP fish salvage facilities, but they are not salvaged in as great a number as are chinook salmon. This could reflect a much lower abundance of steelhead in the Central Valley system or it could be the result of the larger size of steelhead smolts, compared to salmon smolts, when they are emigrating to the ocean (larger fish are better able to avoid entrainment).

The striped bass population of San Francisco Bay and the Sacramento and San Joaquin rivers depends on the Delta for much of its life cycle. The Delta provides important spawning and rearing habitat for striped bass. Reductions in freshwater flow and increases water diversions have resulted in striped bass population declines over the past several decades. Poor water quality in the Delta may also be limiting the survival of young and adults. Striped bass also benefit from high aquatic foodweb productivity. Loss of tidal perennial aquatic, wetland, and slough habitats may also limit production of striped bass. Many striped bass young are lost in water exported through water diversions. Artificially rearing young striped bass salvaged at the south Delta pumping plant fish facilities or supplementing production with hatchery-reared fish may be necessary to sustain the population under present limiting factors.

American shad is an anadromous fish that spawns in the Sacramento River and its major tributaries. They pass through the Delta on their upstream spawning migration in spring. In the fall, young migrate through the Delta on their way to the ocean. A portion of the population spawns and rears in the Delta. Low productivity in periods of drought is a concern. American shad production increases with higher late-winter and spring freshwater flow through the Delta in dry and normal rainfall years. Improved aquatic foodweb production and lower relative export rates at water diversions will benefit American Shad.

Many native and non-native fish species are residents of the Delta. Resident fish populations, like delta smelt and splittail, will benefit from improved aquatic habitats and foodweb production. Many native fish species have declined gradually over the past century from loss of habitats and introductions of non-native fishes. More recently, native resident species have further declined from changes in freshwater flow, water diversions, poor water quality, and further non-native species introductions and habitat degradation. For many of these species, improvements in their native habitats such as sloughs and tidal marshes, is essential to their restoration. Native residents will also benefit from more natural freshwater flow patterns, improved water quality, and reduced losses to water diversions.

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

The western spadefoot and California tiger salamander occur throughout much of the Central Valley, San Francisco Bay, and coast ranges and foothills below 3,000 feet, as well as along the coast in the southern portion of the State. Declining populations have warranted their designation as species of special concern and species of concern by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service, respectively. Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of seasonal wetlands and adjacent uplands to other land uses and excessive mortality resulting from introduction of non-native predators and some land use practices.

The California red-legged frog is California's largest native frog. Its habitat is characterized by dense, shrubby riparian vegetation associated with deep, still, or slow-moving water that supports emergent vegetation. The distribution and population of this species has declined substantially, primarily as a result of habitat loss or degradation and excessive predation. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the federal Endangered Species Act and a Species of Special Concern by DFG. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of the loss or degradation of critical wetland and riparian habitats and the introduction of non-native predators.

Once possibly abundant in the Delta, the giant garter snake and western pond turtle are now rare there. Improvements in wetland, riparian, and grassland habitats around the margins of the Delta could greatly benefit these species.

Once abundant in the Delta, Swainson's hawk is now rare. Improvements in agricultural and riparian habitats will aid in the recovery of the Swainson's hawk.

A long-term decline in emergent wetlands has reduced the population of California black rail in the Delta. Restoring emergent wetlands in the Delta should aid in the recovery of the California black rail.

The population of greater sandhill crane in the Central Valley has declined over the past century with the loss of permanent and seasonally flooded wetlands. Improvements in seasonally flooded wetlands and agricultural habitats should help toward recovery of the greater sandhill crane population.

Herons, egrets, and other shorebirds and wading birds breed and winter throughout the Central Valley and the Delta. Their populations depend on aquatic and wetland habitats. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats.

The riparian brush rabbit is associated with riparian habitats of the Central Valley floodplain. It has been eliminated from the Delta from loss of riparian habitat. Elsewhere, the population and distribution of this species have declined substantially, primarily as a result of the loss or degradation of its habitat. The loss of habitat and declining populations have warranted its listing as endangered under the California Endangered Species Act.

The major factor that limits this resource's contribution to the health of the Delta is related to adverse effects of the historical loss and degradation of the mature riparian forests, on which the riparian brush rabbit depends, in the Delta and San Joaquin River floodplain.

Many species of waterfowl overwinter in the Delta and depend on high-quality foraging habitats to replenish their energy reserves. They depend on wetland, riparian, aquatic, and agricultural habitats. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats.

Upland game species are of high interest to recreational hunters in the Bay-Delta and contribute to California's economy through the sale of hunting-related equipment and hunting-related expenditures. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native upland habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

Neotropical bird species breed in North America and winter in Central and South America. Many species of neotropical migratory birds migrate through or breed in the Bay-Delta. These species are a significant component of the ecosystem. These species are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures. There have been substantial losses of historic habitat used by these species and available information suggests that population levels for many of these species is declining.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

The Lange's metalmark and the delta green ground beetle, both federally listed endangered species, and the valley elderberry longhorn beetle (VELB), a federally listed threatened species, are respectively associated with inland dune, vernal pool, and riparian habitats. The distribution and populations of these species have declined substantially, primarily as a result of the loss or degradation of these habitats within their range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

Once abundant in riparian woodlands of the Delta, yellow-billed cuckoo have declined with the loss of riparian habitats there. The yellow-billed cuckoo will benefit from improvements in habitat that result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Delta.

### List of Species to Benefit from Restoration Actions in the Delta Ecological Management Zone

- delta smelt
- longfin smelt
- green sturgeon
- Sacramento splittail
- chinook salmon (all runs)
- steelhead trout
- lamprey (all species)
- California black rail
- Swainson's hawk
- special status plant species
- Sacramento perch
- riparian brush rabbit
- greater sandhill crane
- western yellow-billed cuckoo
- California red-legged frog
- western pond turtle
- Lange's metalmark butterfly
- native resident fishes
- migratory waterfowl
- shorebird guild
- wading bird guild
- neotropical migratory bird guild
- Bay-Delta foodweb organisms
- white sturgeon
- striped bass
- American shad
- non-native warmwater gamefish
- upland game

## Descriptions of Ecological Management Units

### North Delta Ecological Management Unit

The North Delta Ecological Management Unit is bounded on the south and east by the Sacramento River. Notable features are the Yolo Bypass, the Sacramento deep water channel, the Cache Slough complex, the Sacramento River and adjoining sloughs, the Snodgrass Slough and Stone Lakes complex, and the Delta Cross Channel (DCC) gates which, when open, allow Sacramento River water to flow into the forks of the lower Mokelumne River. Land elevations generally range from 5 feet below to 10 feet above mean sea level.

The size of the unit is approximately 235,000 acres. As with the Delta's other units, the primary land use is agriculture with more than 60% or 141,000 acres in field crops, orchards, and vineyards. Approximately 5% of the unit consists of riparian, oak woodland, freshwater marsh, and seasonal wetland. (See tables in this section.) Much of the permanent and seasonal wetland habitat is found in the Yolo Bypass, Cosumnes River Preserve, and Stone Lakes area.

**North Delta Ecological Management Unit Land Use**

| Land use | *Acres* |
|---|---|
| Non-flooded Ag | *118,011* |
| Flooded Ag | *14,528* |
| Orchard | *2,832* |
| Vines | *5,805* |
| Total cultivated | *141,176* |
| Grass | *42,194* |
| Other | *52,480* |

Hydraulic processes in the North Delta Ecological Management Unit are influenced by tides, upstream water releases, weather, channel diversions, and river inflow. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands and natural marsh successional processes. Tidal action and floodwater discharges from the rivers and Yolo Bypass transport nutrients and organic carbon into aquatic habitats of the Delta and San Francisco Bay.

Hydraulic processes have been modified in the North Delta Ecological Management Unit since the 1890s. Reductions in flow from the Mokelumne River began in the early 1890s with diversions by the Woodbridge Irrigation District. Further diversions began with the completion of the Mokelumne River Aqueduct in the 1930s. Additional agricultural diversions from the river were developed in the 1960s when the present level of diversions from the Mokelumne River was reached. The construction of the Yolo Bypass significantly altered hydraulic patterns during above normal and wet water years. The DCC gates began operation in 1951 and increased the flow of Sacramento River water into the East Delta Ecological Management Unit and away from the mainstem Sacramento River below Walnut Grove.

Hydraulic patterns have been further modified by the significant export pumping beginning in 1951 for the CVP and in 1968 for the SWP. The Barker Slough pumping plant at the east end of Lindsey Slough in the Cache Slough complex was completed in 1988; it exports water directly from the North Delta Ecological Management Unit to the North Bay Aqueduct.

Current hydraulic conditions in the North Delta Ecological Management Unit affect the ability of this Ecological Management Unit to support channels with suitable residence times and natural net flows; to provide adequate transport flows to the lower estuary; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

The effects of many small unscreened diversions in the North Delta Ecological Management Unit are undocumented.

## East Delta Ecological Management Unit

The East Delta Ecological Management Unit is bounded on the northwest by the Sacramento River; on the northeast by the Mokelumne and Cosumnes rivers; and on the south by Highway 12, the South Fork of the Mokelumne River, White and Disappointment Sloughs, and the San Joaquin River. Notable features are Georgiana Slough, the DCC, the Cosumnes River Preserve, and the Woodbridge Ecological Reserve.

Land elevations in this unit generally range from 10 feet below to 10 feet above mean sea level with the western half of the unit ranging from 10 feet below to 5 feet below mean sea level and the eastern half ranging from 5 feet below to 10 feet above mean sea level. These elevations are generally higher that elevations in other regions of the Delta. Elevation is an important factor in evaluating the quality of habitats and in designing habitat restoration projects.

This Ecological Management Unit consists of more than 100,000 acres. It contains both forks of the Mokelumne River, the Cosumnes River, three dead-end sloughs (Beaver, Hog, and Sycamore), and important waterfowl wintering and sandhill crane foraging and roosting areas. As with the Delta's other units, the primary land use is agriculture with more than 68% in field crops, orchards, and vineyards. (See the table in this section for land use acreage.)

Less than 5% of the east Delta consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitats. Much of the riparian and permanent and seasonal wetland habitats are found along the Cosumnes and Mokelumne rivers and in the White Slough Wildlife Area.

**East Delta Ecological Management Unit**
**Habitat Acreage**

| Habitat | Acres |
|---|---|
| Riparian scrub | 714 |
| Riparian woodland | 2,201 |
| Fresh emergent wetland (marsh) | 1,270 |
| Seasonal wetland | 635 |
| **Total** | **4,820** |

Hydraulic processes in the east Delta are influenced by tides, river inflow, weather, channel diversions, and upstream water releases. Unimpeded tidal action into tidal wetlands affects the habitat's sediment and nutrient supplies. These supplies influence the natural marsh successional processes. Tidal outflows transport nutrients and carbon into Bay-Delta aquatic habitats.

**East Delta Ecological Management Unit**
**Land Use**

| Land Use | Acres |
|---|---|
| Non-flooded Ag | 58,937 |
| Flooded Ag | 6,054 |
| Orchard | 870 |
| Vines | 2,653 |
| Total cultivated | 68,514 |
| Grass | 10,906 |
| Other | 21,152 |
| **Total** | **100,572** |

Hydraulic processes have been modified in the east Delta since the 1800s. Reductions in flow from the Mokelumne River began in the late 1800s and continued to decline into the 1960s. The DCC gates began operating in 1951 and increased the flow of Sacramento River water into the East Delta Ecological Management Unit. Hydraulic patterns have been further modified by the significant export pumping, which began in 1951 for the CVP and in 1968 for the SWP.

Current hydraulic conditions in the east Delta are unhealthy. These conditions reduce the ability of this Ecological Management Unit to provide suitable residence times and more natural net flows, to provide adequate transport flows to the central and west Delta, and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

The effects of the many small unscreened diversions in the east Delta are unknown.

## South Delta Ecological Management Unit

The South Delta Ecological Management Unit is bounded on the north by the San Joaquin River, Turner Cut, Whiskey Slough, Trapper Slough, Victoria Canal, and Italian Slough. Notable features are the San Joaquin, Old, and Middle rivers; Clifton Court Forebay; and the State and federal fish protection and export facilities. Land elevations generally range from 10 feet below to 10 feet above mean sea level. Only about half of the unit is at or slightly higher than sea level.

This Ecological Management Unit consists of more than 177,000 acres. The primary land use is agriculture with more than 60% in field crops, orchards, and vineyards. Less than 2% of this Ecological Management Unit consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitats. Much of the riparian and wetland habitat is found in narrow bands along the San Joaquin River and on small channel islands in Old River. (See tables in this section for acreages.)

Hydraulic processes in the south Delta are influenced by tides, river inflow, weather, channel diversions, temporary rock barriers in Middle River, Old River at Tracy, head of Old River, Grantline Canal, and water releases from upstream reservoirs. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies. These supplies influence the natural marsh successional processes. Outflows from tidal wetlands transport nutrients and carbon into aquatic habitats of the Bay-Delta.

Hydraulic processes have been modified in the south Delta since the 1800s. Further reduction in flow started in the 1930s with the completion of the Hetch Hetchy Aqueduct from the Tuolumne River. In the early 1940s, construction of Friant Dam began to significantly alter hydraulic patterns, particularly during drier water years. The South Bay Aqueduct began diversions directly from the South Delta Ecological Management Unit starting in 1962. Hydraulic patterns were further modified by the significant export pumping near Tracy, which began in 1951 for the CVP and in 1968 near Byron for the SWP.

**South Delta Ecological Management Unit Habitat Acreage**

| Habitat | *Acres* |
|---|---|
| Riparian scrub | *899* |
| Riparian woodland | *263* |
| Fresh emergent wetland (marsh) | *650* |
| Seasonal wetland | *430* |
| **Total** | *2,242* |

Current hydraulic conditions in the south Delta are unhealthy and affect the ability of this Ecological Management Unit to support channels with suitable residence times and more natural net flows; to provide adequate transport flows to the entrapment zone; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

**South Delta Ecological Management Unit Land Use**

| Land Use | *Acres* |
|---|---|
| Nonflooded Ag | *98,269* |
| Flooded Ag | *1,909* |
| Orchard | *3,668* |
| Vines | *3,466* |
| Total cultivated | *107,312* |
| Grass | *40,483* |
| Other | *29,434* |
| **Total** | *177,229* |

While the effects of many small unscreened diversions in the south Delta are undocumented, effects of the two large export facilities on nearly all Delta anadromous and resident fishes have been well described and are very significant (See Water Diversions Vision in Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed.)

## Central and West Delta Ecological Management Unit

The Central and West Delta Ecological Management Unit is bounded on the west and north by Suisun Bay, the Sacramento River, Highway 12, the South Fork of the Mokelumne River, and White and Disappointment Sloughs; and on the south by the San Joaquin River, Turner Cut, Whiskey Slough, Trapper Slough, Victoria Canal, and Italian Slough. Notable features are the

San Joaquin and Sacramento rivers, Franks Tract, the channel islands in Middle and Old rivers, and Potato and Disappointment Sloughs. Land elevations generally range from 10 feet below to as deep as 21 feet below mean sea level. This Ecological Management Unit consists of more than 200,000 acres. It contains most of the mainstem of the San Joaquin River in the Delta. Agricultural uses account for 48% of the area and include field crops, orchards, and vineyards. Approximately 3% of the area consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland. Much of the riparian and wetland habitat is found on the extensive network of small channel islands in Old and Middle rivers; on White, Potato, and Disappointment Sloughs; along the edges of Big Break and Franks Track; on the Lower Sherman Island Wildlife Area; and on adjacent tide lands on both sides of the Sacramento River channel between Collinsville and Rio Vista, including Decker Island and adjacent channels. (See the table in this section for habitat acreage.)

**Central and West Delta Ecological Management Unit Habitat Acreage**

| Habitat | *Acres* |
|---|---|
| Riparian scrub | *1,004* |
| Riparian Woodland | *248* |
| Fresh emergent wetland | *5,040* |
| Seasonal wetland | *544* |
| ***Total*** | ***6,836*** |

The central and west Delta contains most of the heavily subsided (sunken) islands in the Delta. Although nearly 98% of this unit was not reclaimed until after 1900, the highly organic soils of this unit have oxidized at an accelerated rate. This has resulted in subsidence (sinking) of 20 to 30 feet in many places. The subsidence has led to serious potential erosion of the levees around the islands and numerous levee breaks in the last several decades.

The central and west Delta has some of the highest levels of wintering waterfowl within the Delta. They use seasonally flooded croplands on the deeper islands in this unit. The California Department of Water Resources is one of the most significant landowners in this unit owning most of Twitchell and Sherman islands.

Hydraulic processes in the central and west Delta are influenced by tides, river inflow, weather, channel configuration, water diversions, and river inflow. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands to complement natural marsh successional processes. Tidal action associated with flows out of tidal wetlands transport nutrients and organic carbon into aquatic habitats of the Bay-Delta.

Hydraulic processes have been modified in the central and west Delta since the 1800s. The South Bay Aqueduct began diversions directly from the south Delta starting in 1962. Deliveries to the Contra Costa Canal began in 1962 directly from Rock Slough in the western portion of this unit. Hydraulic patterns were further modified by the significant export pumping, which began in 1951 for the CVP and in 1968 for the SWP.

Current hydraulic conditions in the central and west Delta are unhealthy. The ability of this Ecological Management Unit to maintain suitable residence times and provide more natural flows are restricted. These restrictions inhibit adequate transport flows to the entrapment zone and reduce high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

In addition to many small unscreened agricultural diversions (e.g., siphons and pumps), electric generating stations divert up to 1,500 cfs of Delta water. The water is diverted at Antioch, along the San Joaquin River channel, for cooling purposes. Some juvenile Delta fish are stressed or killed in the water diverted for plant cooling. Though the amount of heat added to the Delta is small, it is locally measurable. This combined with other heated discharges contributes to significant seasonal warming of Delta waters.

## VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Sacramento-San Joaquin Delta Ecological Management Zone is to achieve a healthier system that better provides for the ecological needs of plants and animals using the system. A healthy ecosystem will have more natural freshwater flow and channel hydraulic patterns. A more natural channel configuration with greater amounts of slough and permanent and seasonal wetland habitats will provide more habitat for fish, waterfowl, and wildlife, and improve aquatic foodweb production and water quality. Improvements in riparian vegetation along waterways will reduce heating of the water and provide habitat for fish and wildlife. A healthy Delta ecosystem will lead to improved survival of anadromous fish that depend on the Delta for a portion of their life cycles, including chinook salmon and steelhead, striped bass, white and green sturgeon, and American shad. A healthy Delta will also help toward improving the native resident fish community including delta smelt and splittail, as well as resident wildlife, migratory waterfowl, neotropical birds, and special-status plants and plant communities.

A restored Delta ecosystem will have improved ecological processes and habitats and reduced stressors. Ecological processes that will be improved include freshwater inflow and outflow, Delta hydraulics, channel configuration, water temperature, floodplain processes, and aquatic and terrestrial foodweb productivity. There will be substantial increases in the acreage of tidal emergent wetlands, seasonal and permanent nontidal wetlands, and shallow water, riparian, and tidal slough habitats. Stresses from land use, urban and industrial development, contaminants, land reclamation, water diversions, flood control (i.e., levees and bank protection), non-native plant and animal species, recreational activity (e.g., boating), water conveyance structures, livestock grazing, and agricultural practices will be reduced.

Following restoration, the Delta will be a better fish spawning, rearing, and migration habitats. A healthy Delta will be more effective in nutrient cycling and will increase primary (plant) and secondary (animal) productivity. Productivity will increase through improved freshwater inflow and outflow, longer hydraulic residence time in Delta channels, and an increase in the amount of tidal wetlands. Improved Delta productivity will also improve the productivity of northern San Francisco Bay.

Both the endangered winter-run chinook salmon and the threatened delta smelt will benefit from improved Delta inflow and outflow during the late winter and spring, greater estuary (river mouth) foodweb productivity, riparian and wetland habitat improvements, and improved screening systems at water diversions.

Much of the new fish and wildlife habitats will come from agricultural lands that are either no longer productive or too expensive to maintain (e.g., levee maintenance costs are too high). These lands will be purchased from willing sellers. Productive agricultural lands will continue to be an integral part of the Delta habitat mosaic and will be protected by upgrading channel configurations and levees.

The Delta's levee system will be effectively maintained to reduce the risk of failure. This will also minimize loss of water quality (e.g., saltwater intrusion) and loss of high-value wildlife habitat and agricultural land. Riparian, wetland, and aquatic habitats along the levees will be improved where possible. In those areas where leveed lands can eventually be restored to tidal action, the exterior levees will be maintained until the island interiors are restored to the proper elevations necessary to support the desired habitats.

A basic restoration strategy is to protect and enlarge areas of remaining native habitats and establish the connectivity of these areas. For example, the Cosumnes River Preserve (Badger Creek Marsh) supports a sizable population of giant garter snake. Caldoni Marsh (White Slough Wildlife Area) west of Lodi is also an area of several recent and historical giant garter snake sightings. Stone Lakes Refuge-Morrision Creek drainage and the Yolo Basin also contain suitable garter snake habitat, though population sizes are thought to be quite small. Restoring connectivity of these areas would benefit giant garter snakes and contribute to their recovery by providing corridors for the reestablishment of historic population. Such areas in the Delta include:

- the Cache Slough complex,
- Stone Lakes,
- the Cosumnes River Preserve in the north Delta, and
- the Sherman Island Wildlife Area in the western Delta.

Benefits to species and habitats will come predominantly through changes to important physical processes. These processes include:

- freshwater flow into and through the Delta
- hydraulic conditions within Delta channels, and
- the channel configuration of the Delta.

Increasing the amount of the floodplain that is inundated by flood waters and tides, and increasing the amount of shallow water and shorelines will increase tidal aquatic, wetland, and riparian habitats. Habitat improvements will be made in concert with floodplain and levee improvements. Levees will be rebuilt and maintained to include shallow water and riparian habitats that not only protect the integrity of the levees, but also provide valuable fish and wildlife habitats. Agricultural lands on Delta islands will be managed to better support waterfowl and wildlife. Tidal sloughs and creeks will be restored to their former health from improved channel hydraulics, water quality, and riparian vegetation, and reductions in non-native aquatic plants (e.g., water hyacinth).

To ensure this recovery, it will be necessary to reduce stressors. Examples of stressors include the alteration of Delta hydraulic patterns by pumping in the South Delta, unscreened or poorly screened diversions, non-native invasive plant species (e.g., water hyacinth), toxic substances, and human disturbance such as erosion of sensitive habitats from boat wakes. In some cases, fish and wildlife may need temporary or even long-term support through artificial habitat construction, reductions in legal and illegal harvest, or artificial reproduction (e.g., hatcheries).

Improvements to restore the health of the estuary need to be made in a way that contribute to the quality of life for Delta fish and wildlife populations, while protecting the region's agricultural economy and preserving landowner property rights. Rebuilt levees will protect valuable agricultural lands and other properties. Improved fish and wildlife populations will benefit recreation. Greater areas of wetlands and riparian habitats will benefit water quality. With restoration, the Delta would provide improved educational and recreational opportunities. The Delta will provide increased public opportunities for wildlife observation, photography, nature study and wildlife interpretation, fishing, hunting, picnicking, and other activities in a manner that is consistent with maintaining the fish and wildlife values of the Delta and protecting adjacent private properties.

Attaining this vision requires extensive efforts in the Delta, and in watersheds above the Delta. For this reason, this Delta vision is closely tied to the visions for the other 13 Ecological Management

Zones. Important ecological processes such as streamflow are controlled by upstream reservoirs and watersheds to the Delta. Delta habitat and the productivity of that habitat are greatly dependent on physical, chemical, and biological processes upstream of the Delta.

A focus on natural processes may reduce the need for measures that artificially maintain habitat and plant and animal populations (e.g., hatcheries). It may be necessary, however, to artificially sustain habitats, severely inhibit stressors, and increase population abundance until such time when natural ecological processes and functions are restored. This will be particularly true during the recovery period.

## INTEGRATION OF ACTIONS FOR STAGE 1 IMPLEMENTATION

Stage 1 actions are those actions to be implemented during the first 7 years of the program. The selection of Stage 1 actions is guided by the Strategic Plan for Ecosystem Restoration (1999). The Strategic Plan identifies 12 important issues related to substantial uncertainties about Bay-Delta ecosystem dynamics that should be addressed by adaptive management and adaptive probing early in Stage 1. Many of the issues address the uncertainty resulting from incomplete information and unverified conceptual models, sampling variability, and highly variable system dynamics.

Relevant issues in the Sacramento-San Joaquin Delta Ecological Management Zone that need resolution during Stage 1 include:

- The impact of introduced species and the degree to which they may pose a significant threat to reaching restoration objectives.
- Recognition that channel dynamics, sediment transport, and riparian vegetation are important elements in a successful restoration program and the need to identify which parts of the system can be restored to provide the desired benefits.
- Development of an alternative approach to manage floods by allowing rivers access to more of their natural floodplains and integrating ecosystem restoration activities with the Army Corps of Engineers' Comprehensive Study of Central Valley flood management programs.
- Increasing the ecological benefits from existing flood bypasses, such as the Yolo Bypass, so that they provide improved habitat for waterfowl, fish spawning and rearing, and possibly as a source of food and nutrients for the estuarine foodwebs.
- Thoroughly testing the assumptions that shallow water tidal and freshwater marsh habitats are limiting the fish and wildlife populations of interest in the Delta.
- A better understanding of the underlying mechanisms of the X2 salinity standard in the Delta and the resultant effects on aquatic organisms.
- A need to better understand the linkage between the decline at the base of the estuarine foodweb and the accompanying decline of some, but not all, species and trophic groups.
- Clarifying the extent to which entrainment at the CVP and SWP pumping plants affects the population size of species and invertebrates.
- Clarifying the suitability and use of the Delta for rearing by juvenile salmon and steelhead.

The proposed Stage 1 approach for the Sacramento-San Joaquin Delta Ecological Management Zone is to broadly design and implement actions that will make a substantial contribution to developing aquatic and terrestrial habitat corridors through the Delta which connect with upstream areas. In addition to the focus on the corridor concept, a variety of general actions will be implemented. Implementation of these actions and linking their implementation with adaptive management through the Comprehensive Monitoring, Research and Monitoring Program will be major steps toward resolving the important Stage 1 issues and will set the direction for subsequent implementation stages.

The three major habitat corridors envisioned include the following:

- **The North Delta Habitat Corridor** will provide a large, contiguous habitat corridor connecting the mosaic of tidal marsh, seasonal floodplain, riparian and perennial grassland habitats in the Yolo Bypass, Cache Slough Complex, Jepson Prairie Preserve, Prospect Island, Little Holland Tract, Liberty Island, and Steamboat Slough.

- **The East Delta Habitat Corridor** will restore a large, contiguous corridor containing a mosaic of habitat types including tidal perennial aquatic, riparian and riverine aquatic habitat, freshwater fish habitat, essential fish habitat, and improved floodplain-stream channel interactions along the Cosumnes River. The focus area includes the South Fork Mokelumne River, East Delta dead-end sloughs, Georgiana Slough, Snodgrass Slough, and the Cosumnes River.

- **The San Joaquin River Habitat Corridor** will provide a contiguous habitat corridor of tidal perennial aquatic habitats, riparian and riverine aquatic habitat, freshwater fish habitat, essential fish habitat, and improve river-floodplain interactions.

In addition to the three habitat corridors, many other restoration actions are proposed for implementation during Stage 1. These additional actions range from conversion of Frank's Tract to shallow water habitats to developing a ballast water management program to halt the accidental introductions of invasive aquatic organisms.

The proposed Stage 1 actions are described in the Restoration Targets and Programmatic Actions section.

# Visions for Ecological Management Units

## North Delta Ecological Management Unit

Habitat restoration, fish passage improvement, and floodplain modifications are the primary focus of the restoration program in the North Delta Ecological Management Unit Restoring a mosaic of tidal emergent wetland and SRA habitat at the ecological-unit level should provide essential resources for all species, particularly communities or assemblages of species that have declined significantly within the Delta.

Habitat restoration will focus on four areas:

- the Yolo Bypass including shallow agricultural islands at the south end of the bypass (i.e., Prospect, Little Holland, and Liberty)

- tidal sloughs between the Sacramento Ship Channel and the Sacramento River (i.e., Steamboat, Miner, Oxford, and Elk)

- the Stone Lakes-Cosumnes Preserve complex, and

- the main channel of the Sacramento River from Sacramento to Rio Vista.

Seasonal patterns of freshwater inflow from the Sacramento River, Yolo basin (Cache and Putah creeks), and the Cosumnes and Mokelumne rivers would be improved. Fish passage problems in the Yolo Bypass, DCC, Sacramento Ship Channel, and Snodgrass Slough should be resolved.

Unscreened diversions in important habitat and migration pathways should be screened. Non-native plants will be controlled.

The vision for the North Delta Ecological Management Unit focuses heavily on habitat restoration in the major subunits and the creation of a North Delta habitat corridor. In the Yolo Bypass, channels should be constructed to connect to channel improvements in the Yolo basin (i.e., connections with Putah and Cache creeks, the Colusa drain, and the Sacramento River through the Sacramento and Fremont weirs). These channels should be constructed as permanent sloughs along either side of the bypass.

The sloughs will feed permanent tidal wetlands constructed along the bypass and connected with existing wetlands within the Yolo Basin Wildlife Area. The sloughs would provide rearing and migrating habitat for juvenile and adult salmon, and other native fishes. The sloughs would drain into extensive marsh-slough complexes developed in shallow islands (i.e., Liberty, Little Holland, and Prospect) at the lower end of the bypass. These changes, in conjunction with structural improvements to the bypass floodway (e.g., reducing the hydraulic impedance of the railroad causeway paralleling Interstate 80, and removing levees along the lower Sacramento Ship Channel (see below), will retain and possibly increase the flood bearing capacity of the Yolo Bypass.

To the east of the Yolo Bypass, the vision includes some improvements to the Sacramento Ship Channel. Fish passage problems at the gate structure on the Sacramento River at the north end of the ship channel should be resolved by constructing fish passage facilities. Connections between the ship channel and the new island complexes at Liberty, Little Holland, and Prospect Islands would be considered.

The major sloughs to the east between the ship channel and the Sacramento River, including Miner, Steamboat, Oxford, and Elk, should be improved as salmon migration corridors. A riparian habitat would be improved along these sloughs. Setback levees along portions of these sloughs may expand the slough and adjacent marsh complexes. Increases in the hydraulic connections at the northern end of the slough complex on the Sacramento River and at the southern end at Prospect Island would increase tidal and net flows through the complex, which along with habitat improvements, could represent important rearing and migrating habitat improvements for salmon and other anadromous and resident fish.

Along the Sacramento River channel between Sacramento and Rio Vista, restoration is limited to improvements to riparian vegetation along the major federal levees and to protection and possible improvements to retain remaining shallow-water habitat and tule berms along the river sides of the levees. In addition, habitats would benefit from improving and maintain flows that contribute to riparian regeneration. These habitats may be important spawning habitat of delta smelt and other native Delta fishes and important rearing and migratory habitats of juvenile salmon and steelhead.

The vision for the Stone Lakes-Snodgrass Slough-Lower Cosumnes/Mokelumne complex at the northeast side of the North Delta Ecological Management Unit includes extensive habitat improvements. These improvements will be consistent with increasing the connection of wetlands and riparian woodlands in the Stone Lakes and Cosumnes preserves. Remnant marshes, riparian woodlands, and tidal sloughs along Snodgrass Slough would be protected and improved. Some small units of leveed agricultural lands would be converted to marsh-slough complexes. Flood control levees would be upgraded and riparian and shallow-water habitats improved on the waterside of the levees. Gated connections with appropriate fish passage facilities (and, potentially, screens) would be considered on the Sacramento River at the north end of Snodgrass Slough and Morrison Creek near Hood to provide this portion of the unit with water at a level consistent with pre-levee flows. Water hyacinth infestations would be controlled throughout the complex. All unscreened agricultural diversions located along salmon migratory corridors or spawning habitat of delta smelt would be screened.

Changes in the operation of the DCC gates would be considered depending on which program alternative is chosen.

## EAST DELTA ECOLOGICAL MANAGEMENT UNIT

The vision for the East Delta Ecological Management Unit focuses on restoration of native Delta habitats that will improve spawning, rearing, and migration habitats of native Delta fishes, as well as provide extensive new amounts of wetland, waterfowl, and wildlife habitat. Restoring a mosaic of habitat conditions at a landscape level should provide essential resources for all species, especially communities or assemblages of species that are rare within the Delta. Improvements along the south Mokelumne River and adjoining dead-end sloughs on the east edge of the Delta should be the focus of restoration efforts.

The vision for Georgiana Slough, Snodgrass Slough, the Cosumnes River and the South Ford of the Mokelumne River channel is to improve riparian and tidal marsh habitats and restore ecological processes, such as floodplain-river interactions, to the degree feasible to create a sustainable East Delta habitat corridor.

The vision for the east side of the unit along the South Mokelumne River and its adjoining dead-end sloughs (Beaver, Hog, and Sycamore) is extensive restoration of native Delta habitats. Levee setbacks and improvements along the river and sloughs would be accompanied by shallow-water and riparian habitat improvements.

Subsided leveed lands between the sloughs would be converted to floodplain overflow basins. These floodplains would support non-tidal, permanent tule-marsh wetlands, or seasonal agricultural production. After many decades of flooding, marsh growth, and sediment-laden flood overflow, these floodplains could be converted to tidal wetland.

Tidal headwaters of sloughs and adjacent lands would be opened to provide permanent tidal wetland marsh-slough complexes. Conversion of these agricultural lands would also reduce water diversions (i.e., loss of water and juvenile fish). Levee setbacks and a wider floodplain would improve habitat for fish including resident delta smelt and splittail and seasonal migrant salmon and steelhead from the Cosumnes and Mokelumne rivers.

## SOUTH DELTA ECOLOGICAL MANAGEMENT UNIT

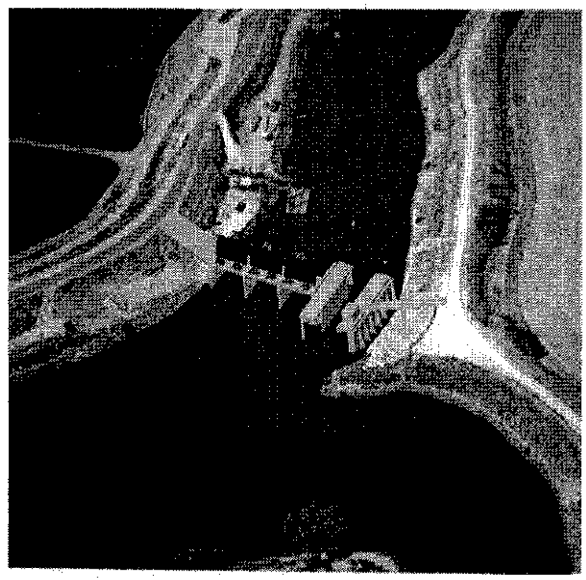
Large-scale habitat restoration, channel and floodplain improvements, hydraulics, and losses at unscreened diversions and water export facilities are the primary focus of the restoration program in the South Delta Ecological Management Unit. Restoring a mosaic of habitat conditions at a landscape level should provide essential resources for all species, particularly communities or assemblages of species that are rare within the Delta.

The vision for the South Delta Ecological Management Unit focuses on restoring floodplain habitat along the lower San Joaquin River between Mossdale and Stockton and improving riparian habitat along leveed sloughs throughout the unit. This is integral to the creation of the San Joaquin River habitat corridor. Improving interior slough complexes of the Old and Middle rivers would depend on which CALFED alternative is chosen for conveyance through the Delta. Minimal improvements would be made under alternatives that use existing Delta channels because these channels would remain major conduits for moving water to the export pumps. Other alternatives would provide more flexibility in the form of improvements in riparian and emergent wetland habitat and channel configurations. Depending on the preferred alternative, the South Delta Ecological Management Unit could be a location in which extensive restoration of tidal emergent wetlands and tidal perennial aquatic habitats occurs. This is influenced by the present land elevations and because land subsidence has been less dramatic that in other regions of the Delta.

A major focus of the vision in the south Delta will be expansion of the floodway in the lower San Joaquin River floodplain between Mossdale and Stockton. Setback levees and overflow basins offer opportunities to increase the flood-bearing capacity of the existing configuration of the river floodplain, as well as potential for creating significant amounts of native tidal emergent wetlands within the floodplain, regardless of which conveyance alternative is chosen.

Another important focus of the vision is to solve the problems associated with the export of water from the south Delta export facilities of the SWP and CVP near Byron and Tracy, respectively. Under all three CALFED alternatives, it is imperative that the loss of juvenile anadromous and resident fishes at the two export facilities be reduced as soon as possible. A new fish screen facility would be constructed that would screen all water for both facilities. The screen system would include a state-of-the-art fish collection, handling, and transport system that would reduce fish losses. Some alternatives would further reduce losses of fish from the south Delta by limiting diversions from the south Delta in seasons when fish are most abundant or vulnerable. Fish losses could also be reduced by providing alternative sources of water to south Delta islands, which would otherwise divert water from existing channels.

A barrier at the head of Old River would be installed to prevent San Joaquin River water and fish from moving into the southern Delta. The barrier would help ensure that San Joaquin River water and juvenile salmon would have some chance of reaching the western Delta and the San Francisco Bay. Precautions would be taken in the operation of the barrier to not cause increased delta smelt, winter-run chinook salmon, and other fishes movement south into the South Delta and greater losses at south Delta export facilities.



Conceptual view of a fish barrier at the Head of Old River (DWR).

## Central and West Delta Ecological Management Unit

Restoring habitat is the primary focus of the restoration program in the Central and West Delta Ecological Management Unit. Restoring a mosaic of tidal emergent wetland and SRA habitat on a large scale should provide essential resources for all species dependent on the Delta. Protecting and enhancing levees around all the deeper islands should include major adjacent shoal and shallow-water habitats, as well as riparian and tule-berm (midchannel islands) improvements. Changes in channel hydraulics will protect and improve habitats in specific sloughs. Water conveyance through the Delta should be concentrated in specific channels that should be reinforced for that purpose, and little habitat restoration should be conducted along these channels so as not to encourage residence of juvenile fishes. Portions of deeper islands should be reclaimed where possible for tidal or nontidal marsh habitat. Unscreened diversions in important migration pathways of salmon and delta smelt should be screened or relocated to other channels.

The vision for the Central and West Delta Ecological Management Unit is to restore fresh emergent wetland habitat, shoal and shallow-water aquatic habitat, and adjacent riparian habitat. Along the main channel of the San Joaquin River where levees are being upgraded; wetland, shoal, shallow-water, and adjacent riparian habitat should be improved. Where feasible, new construction should set back levees on portions of islands where the ratio of levee length to protected agricultural acreage is high. This will potentially reduce levee construction and maintenance costs and provide new tidal shallow-water, slough, wetland, and riparian habitat.

These selected islands would be on higher elevation lands to minimize the need for fill; however, some fill would be needed on deeper corners. This might be closely linked with the LTMS strategy for the beneficial reuse of dredge materials as it would accelerate marsh rebuilding processes. On such setbacks, levees would initially be maintained while fill was applied and habitats developed. Eventually, the levees would be breached or gated to allow tidal flows into the newly developed habitats. In some cases, entire small islands may be reclaimed, similar to the way in which portions of western Sherman Island in the west Delta were reclaimed for aquatic and marsh habitat. Along the margins of the unit selected levees could be breached or removed to provide areas of tidal wetlands and adjacent grasslands. The amount of new habitats potentially derived from these actions represents as much as 10% of the total acreage in the Central and West Delta Ecological Management Unit.

Selected tidal channels and sloughs in the Central and West Delta Ecological Management Unit (e.g., Potato Slough and Disappointment Slough) retain good habitats in the form of midchannel islands, shoreline marshes and riparian woodlands, and shallow waters. These habitats would be protected and would also require active water hyacinth control.

On deeper Delta islands, levees should be upgraded to protect them from catastrophic failure. Portions of or all of some islands would be considered for establishing permanent nontidal wetlands. Approximately 30,000 acres of these islands would be appropriate for consideration of permanent or seasonal wetland development, or combination wildlife habitat and agricultural use. Selected islands may also be appropriate for flood overflow basins or seasonal water storage reservoirs.

Along the west side of the unit in the Highway 4 corridor, there are many opportunities to combine urban, agricultural, and native Delta habitat developments. There are many opportunities for tidal slough and marsh habitat development in this area.

Unscreened diversions along major pathways of salmon and delta smelt would be relocated or screened. Screening systems at Antioch electric power plants would be upgraded to reduce loss of fish to entrainment through or impingement on the fish screens. The extent of screening needs would depend on which program alternative is chosen

## VISIONS FOR ECOLOGICAL PROCESSES

**CENTRAL VALLEY STREAMFLOWS:** Much of the fresh water of the State drains the watersheds of the Central Valley through the Delta. A healthy pattern of freshwater inflow into and through the Delta would entail natural late winter and spring flow events especially in dry and normal water-year types. Such flow events would support many ecological processes and functions essential to the health of important Bay-Delta fish populations. Inflow to the Delta is impaired in dry and normal rainfall years from the storage and diversion of natural inflow to the basin watersheds. The need for inflow coincides with the need for natural flows in the mainstem rivers, their tributaries, and

San Francisco Bay. Increasing low salinity habitat at Roe Island, Chipps Island, and at Collinsville will benefit rearing native fishes dependent on this type of habitat.

**COARSE SEDIMENT SUPPLY:** Maintain a sustainable supply of natural sediments to the Delta. Sediments are one of the basic ecological components contributing to the development of the Delta landscape over the past 6,000 years. Sediments are needed to maintain floodplains, shallow shoals, mudflats, mid-channel islands, and contribute to maintaining and restoring riparian, wetland, and aquatic habitats. In the longer term, sediments may play an important role in reversing land subsidence on many Delta islands.

**NATURAL FLOODPLAINS AND FLOOD PROCESSES:** Expand the Delta floodplain by setting back or removing portions of the levee. This would enhance floodwater and sediment retention in the Delta and provide direct and indirect benefits to floodplain dependent fish and wildlife. Such floodplain expansion should also help alleviate flooding potential in other areas of the Delta.

**CENTRAL VALLEY STREAM TEMPERATURES:** During spring and fall, Delta channels are used by anadromous fish for migrating between rivers and the Pacific Ocean and are used as rearing areas as well. Untimely high water temperatures stress migrating fish by delaying their movement or causing mortality. Improvements in riparian and SRA habitat along Delta channels would improve water temperatures in small but important increments in these areas during critical fall and spring migrating periods. Higher inflow in late winter and early spring will help delay warming of the Delta channels.

**DELTA CHANNEL HYDRAULICS:** Confinement of Delta channels and use of channels to convey water across the Delta has led to reduced productivity and habitat value of Delta channels. Restoration of natural hydraulic conditions in some Delta channels would improve productivity and habitat values.

**BAY-DELTA AQUATIC FOODWEB:** The aquatic foodweb of the Delta, which supports important resident and anadromous fish, has been severely impaired. The major foodweb stressors include drought, reductions in freshwater flow, water diversions, introductions of non-native species (e.g., Asiatic clams), and loss of shallow water and wetland habitats. Proposed improvements in spring flows, channel hydraulics, wetland habitats, and floodplain inundation should lead to a healthier and more productive aquatic foodweb. Improved water quality and greater sediment retention in wetland, riparian, and floodplain habitats will also increase foodweb productivity.

## VISIONS FOR HABITATS

**TIDAL PERENNIAL AQUATIC HABITAT:** Land reclamation in the Delta has reduced the area of tidal aquatic habitats such as small sloughs, ponds, and embayments in tidal wetlands. Increased tidal wetland acreage and associated aquatic habitats will provide additional valuable fish and waterfowl habitats.

**NONTIDAL PERENNIAL AQUATIC HABITAT:** Increasing the area of ponds and lakes on leveed land in the Delta will provide needed habitats for shorebirds, waterfowl, and wildlife.

**DELTA SLOUGHS:** Increasing the number, length, and area of dead-end and open-end sloughs in the Delta will benefit native fishes, as well as waterfowl, wildlife, and neotropical songbirds.

**MIDCHANNEL ISLANDS AND SHOALS:** Channel islands in the Delta have associated remnant shallow-water, wetland, and riparian habitats that are valuable for fish and wildlife and sensitive plants. Maintaining and restoring these islands is important given the lack of such habitats and limited potential for creating new habitats within the Delta channels.

**FRESH EMERGENT WETLAND HABITAT:** Restoring tidal and nontidal marshes in the Delta will benefit foodweb productivity and water quality. It will also provide important habitat for fish, waterfowl, wildlife, and sensitive plant species and communities.

**SEASONAL WETLAND HABITAT:** Increased seasonal flooding of leveed lands and flood bypasses will provide important habitats for shorebirds, waterfowl, and raptors, particularly Swainson's hawk, as well as native plants and wildlife. Flooding and draining of seasonal wetlands also contributes to the aquatic and terrestrial foodwebs of the Delta and Bay.

**RIPARIAN AND RIVERINE AQUATIC HABITAT:** Restoring riparian (waterside) vegetation corridors along levees and associated SRA habitats will benefit many native fish and wildlife species dependent on this type of habitat.

**INLAND DUNE SCRUB:** Protecting remaining inland dune scrub habitat will protect special-status wildlife populations and special plant species.

**PERENNIAL GRASSLANDS:** Protecting and improving perennial grassland habitats will benefit special-status wildlife populations, special status plants, and help protect adjoining wetland habitats.

**FRESHWATER FISH HABITAT:** Freshwater fish habitats are an important component needed to ensure the sustainability of resident native and anadromous fish species. The Delta provides floodplain pool ephemeral water habitat, sloughs, oxbow lakes, and backwater habitats, valley floor rivers which include the main channels of the Sacramento and San Joaquin (Moyle and Ellison 1991). The quality of freshwater fish habitat in the Delta will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats and tidally influenced shallow water habitats.

**ESSENTIAL FISH HABITAT:** The Delta has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in the Delta include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

**AGRICULTURAL LANDS:** Improving habitats on and adjacent to agricultural lands in the Delta will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit special-status wildlife such as sandhill cranes.

## VISIONS FOR REDUCING OR ELIMINATING STRESSORS

**WATER DIVERSIONS:** Screening, consolidating, reducing, and relocating water diversions will reduce loss of important fish and aquatic foodweb organisms. These actions will also improve Delta outflow and channel hydraulics. Relocating south Delta diversion and rehabilitating fish facilities should greatly reduce the annual losses to these diversions. Improved screening at large Delta power plants should reduce entrainment and impingement losses of many important Delta fish species.

**LEVEES, BRIDGES, AND BANK PROTECTION:** Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat throughout the Delta. Habitat improvement on levees and shorelines should help restore biodiversity and ecological functions needed for aquatic and wildlife resources of the Delta.

**DREDGING AND SEDIMENT DISPOSAL:** Reducing the loss of and degradation to important aquatic habitat and vegetated berm islands caused by dredging activities would protect, restore, and maintain the health of aquatic resources in and dependent on the Delta.

**INVASIVE SPECIES:** Over the past several decades, the accidental introduction of many marine and estuarine organisms has greatly changed the plankton and benthic (bottom and shore dwelling) invertebrates of the Delta. These organisms come mainly from the ballast waters of ships from the Far East. The introduction of these invasive species has had further ramifications up the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta. Border inspections and enforcement of regulations regarding ballast water releases should reduce the number of invasions each year to the Delta. Where invasive species have become a serious problem, possible means will be developed to control their distribution and abundance.

**PREDATION AND COMPETITION:** The numbers of predatory fish at certain locations in the Delta (e.g., Clifton Court Forebay) are high and contribute to the loss of resident and anadromous fish. Reductions in these local predator concentrations may reduce predation on important fish, including juvenile chinook salmon, steelhead, striped bass, and delta smelt. Predator control would also improve fish salvage at the State Water Project facilities at Clifton Court Forebay. Programs and projects that exclude fish such as salmon and delta smelt from areas that harbor concentrations of predators will contribute to reducing the adverse effects of predation.

**CONTAMINANTS:** Reducing toxin inputs in discharges and from contaminated sediments is essential to maintain water quality. Reduced concentrations in waters entering the Delta should lead to lower concentrations in Delta water and in fish and invertebrate tissues. Fewer health warnings for human consumption of Delta fish and improved foodweb productivity would also be expected.

**HARVEST OF FISH AND WILDLIFE:** The legal and illegal harvest of fish may limit recovery of some populations in the Delta and its watersheds. Increasing enforcement will help reduce illegal harvest of striped bass and sturgeon in the Delta. Increased enforcement and public education should lead to reduced frequency of violations per check by enforcement personnel.

**STRANDING:** The loss of aquatic organisms, primarily fish species, will be better understood and remedial actions developed and implemented. The primary focus of this effort will be in the Yolo Bypass.

**DISTURBANCE:** Boat traffic in the Delta contributes to the erosion of remaining shallow water, riparian, and wetland habitats along Delta channels. Reducing boat speeds and traffic in channels where remnant or restored habitats are susceptible to wave erosion damage would help preserve existing remnant habitat and ensure the success of habitat restoration efforts. Reduced rates of erosion and loss of shoreline habitats would be expected in areas of reduced disturbance. Enforcement and /or stricter boating regulations on bilge pumping, refueling, and oil changes will result in decreased contaminant loading and improve water quality. Boating also adversely affect two critical biological events in the Delta: spawning seasons for fish, particularly shallow water spawners such as delta smelt, and wintering periods for waterfowl and shorebirds.

## VISIONS FOR SPECIES

**DELTA SMELT:** The vision for delta smelt is to recover this State- and federally listed threatened species. Recovery of the delta smelt population in the Delta will occur through improved Delta inflow, greater foodweb productivity, increased areas and quality of aquatic habitats, including the South Delta, and reduced effects of water diversions. Higher production should be apparent in dry and normal water year types in response to improvement in flows, habitats, and foodweb and to reductions in stressors.

**LONGFIN SMELT:** The vision for longfin smelt is to recover this California species of special concern in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb. Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt.

**SPLITTAIL:** The vision for splittail is to recover this federally listed threatened species in order to contribute to the overall species richness and diversity and to reduce conflict between splittail protective measures and other beneficial uses of water in the Bay-Delta. Recovery of the Delta splittail population will occur through increased flooding of floodplains, higher late-winter Delta inflow, and improved tidal aquatic and wetland habitats. Greater production of young would be expected in dry and normal water year types.

**GREEN STURGEON:** The vision for green sturgeon is to recover this California species of special concern and to restore population distribution and abundance to historical levels. Restoration of this species contributes to overall species richness and diversity and reduces conflict between the need for protection for these species and other beneficial uses of water in the Bay-Delta. Green sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food).

**CHINOOK SALMON:** The vision for chinook salmon is to recover all stocks that are listed or proposed for listing under CESA or ESA. Central Valley chinook salmon populations will increase with improved late-winter and spring flows through the Delta, increases in wetland and floodplain habitats, lower spring water temperatures, an improved aquatic foodweb, and reduced effects of water diversions. Survival rates through the Delta should increase. Numbers of young salmon rearing in the Delta should increase with improved winter-spring flows and wetland habitats.

**STEELHEAD TROUT:** The vision for steelhead is to recover this federally listed threatened species. Steelhead will benefit from improved Delta inflow and outflow, channel hydraulics, and increased area of tidal marshlands. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

**LAMPREY:** The vision for anadromous lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability.

**SACRAMENTO PERCH:** The vision for the Sacramento perch is to contribute to the recovery of this California species of special concern and to contribute to the overall species richness and diversity. Although extirpated from the Delta, restoration of Delta islands and heavily vegetated shallow water habitats may contribute to its restoration.

**WHITE STURGEON:** The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Restoration would support a sport fishery for white sturgeon and contribute to overall species richness and diversity and reduce conflict between the need for protection of this species and other beneficial uses of water in the Bay-Delta.

**STRIPED BASS:** The vision for striped bass is to maintain healthy populations, consistent with restoring natives species, to their 1960s levels of abundance to support a sport fishery in the Bay, Delta, and tributary rivers, and to reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta. The striped bass population will benefit from increased inflows to the Delta in late winter and spring, an improved aquatic foodweb, and reduced effects of water diversions. Improvements in water quality and reducing summer losses to diversions may be important in the long-term recovery of striped bass. Given the high reproductive capacity of striped bass, improvements in production of young should quickly follow improvements in flow and foodweb and reductions in stressors.

**AMERICAN SHAD:** The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, to support a sport fishery similar to the fishery that existed in the 1960s and 1970s. Central Valley American shad populations will benefit from improved spring Delta inflow and an improved Delta aquatic foodweb. Populations would be expected to remain stable or increase. Increases would be expected in dry and normal rainfall years.

**NON-NATIVE WARMWATER GAMEFISH:** The vision for non-native warmwater gamefish is to maintain self-sustaining populations, consistent with restoring native species, in order to provide opportunities for consumptive uses such as angling.

**NATIVE RESIDENT FISH SPECIES:** The vision for native resident fish species is to maintain and restore the distribution and abundance of native species such as Sacramento blackfish, hardhead, and tule perch. Many native fish species will benefit from improved aquatic habitats and foodweb. Population abundance indices should remain stable or increase. The distribution of native resident fishes should increase with widespread habitat restoration. The extirpated Sacramento perch could be restored to new habitats in the Delta.

**BAY-DELTA FOODWEB ORGANISMS:** The vision for the Bay-Delta aquatic foodweb organisms is to restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities. Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and evaluating the need to reduce loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Another important element includes reducing the amount of toxic substances entering the system which may adversely affect foodweb organisms.

**WESTERN SPADEFOOT:** The vision for the western spadefoot is to maintain this California species of special concern in the Bay-Delta. Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the western spadefoot. Restoration of aquatic, seasonal wetland, and floodplain habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area.

**CALIFORNIA TIGER SALAMANDER:** The vision for the California tiger salamander is to maintain existing populations of this Federal candidate species in the Bay-Delta. Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the California tiger salamander.

Restoration of aquatic, seasonal wetland, and floodplain habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area.

**CALIFORNIA RED-LEGGED FROG:** The vision for the California red-legged frog is to maintain populations of this federally listed threatened species. Achieving this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable aquatic, wetland, and riparian habitats and reducing mortality from non-native predators will be critical to achieving recovery of the California red-legged frog. Restoration of aquatic, wetland, and riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area.

**GIANT GARTER SNAKE:** The vision for the giant garter snake is to contribute to its recovery in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area.

**WESTERN POND TURTLE:** The vision for the western pond turtle is to maintain the abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the western pond turtle. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

**SWAINSON'S HAWK:** The vision for the Swainson's hawk is to contribute to the recovery of this State-listed threatened species to contribute to the overall species richness and diversity. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected in the Delta as a result of improved habitats.

**CALIFORNIA BLACK RAIL:** The vision for the California black rail is to contribute to the recovery of this State-listed threatened species to contribute to overall species richness and diversity. Restoring emergent wetlands in the Delta should aid in the recovery of the California black rail. Population abundance and distribution should increase in the Delta.

**GREATER SANDHILL CRANE:** The vision for the greater sandhill crane is to contribute to the recovery of this State-listed threatened species is the Bay-Delta. Improvements in pasture lands and seasonally flooded agricultural habitats, such as flooded corn fields, should help toward recovery of the greater sandhill crane population. The population should remain stable or increase with improvements in habitats.

**SHOREBIRDS AND WADING BIRDS:** The vision for shorebird and wading birds is to maintain and restore healthy populations through habitat protection and restoration and reduction is stressors. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats. The extent of seasonal use of the Delta by these birds should increase.

**RIPARIAN BRUSH RABBIT:** The vision for the riparian brush rabbit is to contribute to the recovery of this State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat. Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing five new populations will be critical to the recovery of the riparian brush rabbit. Restoration of riparian habitats in the South Delta Ecological Management Unit of the Sacramento-San Joaquin Delta Ecological Management Zone and the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding.

**WATERFOWL:** The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture as part of the North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Delta and possibly increases in some populations would be expected.

**PLANT SPECIES AND COMMUNITIES:** The vision for plant species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland, riparian, grassland, and upland habitats.

**UPLAND GAME:** The vision is to maintain healthy populations of upland game species at levels that can support both consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. Protecting and restoring existing and additional suitable grassland, seasonal and emergent wetland, midchannel island and shoal, and riparian habitats, and improving management of agricultural lands and reducing the effect of stressors that can suppress breeding success will be critical to maintaining healthy upland game populations in the Bay-Delta.

**NEOTROPICAL MIGRATORY BIRDS:** The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta. Large-scale restoration of nesting habitats will help reduce nest parasitism and predation by creating habitat conditions that render neotropical birds less susceptible to these stressors.

**LANGE'S METALMARK BUTTERFLY:** The vision for Lange's metalmark butterfly is to recover this federally listed endangered species by increasing its distributing and abundance through habitat protection and restoration.

**DELTA GREEN GROUND BEETLE:** The vision for the delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing its populations and abundance through habitat restoration.

**VALLEY ELDERBERRY LONGHORN BEETLE:** The vision for the valley elderberry longhorn beetle is to recover this federally listed threatened species by increasing its populations and abundance through habitat restoration.

**WESTERN YELLOW-BILLED CUCKOO:** The vision for the western yellow-billed cuckoo is to contribute to recovery of this State-listed endangered species. There is no recent occurrence information for the yellow-billed cuckoo in the Delta. However, the cuckoo would become reestablished in the Delta and will benefit from improvements in riparian habitats. Improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Delta.

## Integration with Other Restoration Programs

Attaining the vision for the Delta will involve a long-term commitment with short-term and long-term elements. Short-term elements include features that can and need to be implemented as quickly as possible either because of a long-standing need or a pressing opportunity. Plan elements where need, priority, technical and engineering feasibility, or cost effectiveness are questionable would be long-term. However, even long-term elements would in most cases benefit from short-term pilot studies that would address need, feasibility, science, and cost effectiveness.

Changes in freshwater inflow patterns to the Delta is a long-standing need; however, without developed supplies, the prescribed spring flows may not be possible in all year types. In the short-term, efforts would be made to provide the flows with available CVP water supplies in Shasta, Folsom, and New Melones Reservoirs using water prescribed by the Central Valley Project Improvement Act (§3406 b2 water) and additional water purchased from willing sellers (CVPIA §3406 b3 or CALFED purchased water). The effectiveness of water dedicated for such purposes would be maximized through use of tools such as water transfers. In the long term, additional environmental water supplies may be needed to meet all flow needs.

Related programs in this Ecological Management Zone include the CVPIA and Anadromous Fisheries Restoration Program, the SB 34 levee subvention program, Central Valley Habitat Joint Venture, the Riparian Habitat Joint Venture (a multiagency cooperative effort), Ducks Unlimited's Valley Care program, the Nature Conservancy's Cosumnes River and Jepson Prairie Preserves, the USFWS's Stone Lakes Refuge, the DFG's Yolo Basin Wildlife Area, East Bay Park's Big Break and Little Franks Tract recreation areas, and outreach programs that compensate private landowners who improve wildlife management of their lands. The U.S. Army Corps of Engineer's program to mitigate for habitat losses from levee protection in the Delta should coordinate closely with the restoration program.

Much of the infrastructure to implement the vision for the Delta now exists. Existing programs could implement many of the restoration actions outlined in this vision. In areas where cooperative agency and stakeholder efforts do not now exist, such organizations can be developed to help implement the program. Cooperative efforts where agencies have formed partnerships to restore valuable aquatic, wetland, and riparian habitats in the east Delta would be supported and used as a model for other similar efforts (e.g., the Cosumnes River Preserve, with the Nature Conservancy and Ducks Unlimited). Other examples include the establishment of wildlife refuges at Stone Lakes and the Yolo Bypass, each with multiple partners and commitments. The California Department of Water Resources, DFG, and the U.S. Fish and Wildlife Service (USFWS) own considerable properties in the Delta (e.g., West Sherman Island Wildlife Area), which with funding support can be restored or upgraded to fit the vision. The Interagency Ecological Program (IEP) is an established research and monitoring unit that, with support, can accomplish the expanded evaluation and monitoring needs.

### Endangered Species Recovery Plan Implementation

The ERPP will be an important, if not major, component in the successful implementation of recovery measures for species listed under either the State or Federal ESAs. For example, many of the targets and programmatic actions listed later in this section are derived from existing recovery plans. Two plans of major importance include the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1996) and the NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997).

Because the ERPP addresses endangered species from a broader ecosystem perspective, many restoration actions will benefit broad species communities and the habitats upon which they depend. These include actions to benefit aquatic and terrestrial fish and wildlife species as well as special plants and plant communities.

## CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the Delta Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. The Anadromous Fish Restoration Program of the CVPIA (USFWS 1997) has a goal to double the natural production of anadromous fish in the system over the average production during 1967 through 1991. CVPIA authorized the dedication and management of 800,000 af of CVP yield annually for the purpose of implementing the fish, wildlife, and habitat restoration purposes and measures that include water purchased for inflow to and outflow from the Delta.

## CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture is a component of the USFWS's North American Waterfowl Management Plan, with funding and cooperative project participation by federal, State, and private agencies. New funding sources, including CALFED restoration funds, are being sought to implement the Joint Venture. The Joint Venture has adopted an implementation plan that includes objectives to protect wetlands by acquiring fee-title or conservation easements and to enhance waterfowl habitat in wetlands and agricultural lands. Joint Venture objectives and targets have been adopted by the ERPP.

## SAN JOAQUIN COUNTY HABITAT CONSERVATION PLAN

The San Joaquin County Habitat Conservation Plan is nearing completion and describes mechanisms for offsetting past and future impacts associated with land use changes. The habitat conservation plan outlines an approach for acquiring lands using preservation criteria.

## DELTA WILDLIFE HABITAT PROTECTION AND RESTORATION PLAN

While not a formal plan, this plan is used to guide California Department of Fish and Game (DFG), USFWS, and other agencies' programs to wisely use and protect riparian and wetland habitats in the Bay and Delta. Its goals are to protect and improve habitat and inform the public of the magnitude of problems that threaten wildlife and their habitat. It also provides mechanisms for cooperation between local governments and State and federal agencies.

## CALFED BAY-DELTA PROGRAM

CALFED has funded over 20 ecosystem restoration projects in the Sacramento-San Joaquin Delta. Many of these projects deal with restoration of tidal aquatic habitat and screening of water diversions. Two of the more significant projects address the land subsidence problem, by studying methods to return the land to its pre-disturbance elevation. Department of Water Resources is allowing biomass to accumulate on Twitchell Island to reverse the subsidence. In another project, the United States Geological Survey is studying the movement and availability of sediment supplies in the Delta.

# Linkage to Other Ecological Management Zones

Realizing the vision in this Ecological Management Zone depends in part on achieving the targets in the Sacramento River, Eastside Delta Tributaries, Yolo basin, and San Joaquin River Ecological Management Zones. Targets in the Suisun Marsh/North San Francisco Bay Ecological Management Zone should be pursued in combination with the Delta to restore important rearing habitats, reduce the introduction of contaminants, and control the introduction of non-native aquatic species. Meeting the flow needs for the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers is essential to the Delta freshwater inflow needs. Aquatic, riparian, and wetland corridors in the Yolo and Eastside Delta Tributaries Ecological Management Zones are also directly linked and integral to habitat corridors in the Delta.

One important ecological process that needs further evaluation is sediment. The sediment budget of the Delta is of particular interest and there is a need to quantify sediment input, sediment depositional patterns in the Delta, and sediment output.

# Restoration Targets, and Programmatic Actions

Targets developed for the Sacramento-San Joaquin Delta Ecological Management Zone (and the 13 other ecological management zones) can be classified by their reliability in contributing to attainment of the Strategic Objectives. The target classification system used in the following section is as follows:

| Class | Description |
|---|---|
| ◆ | Target for which additional research, demonstration, and evaluation is needed to determine feasibility or ecosystem response. |
| ◆◆ | Target which will be implemented in stages with the appropriate monitoring to judge benefit and success. |
| ◆◆◆ | Target that has sufficient certainty of success to justify full implementation in accordance with adaptive management, program priority setting, and phased implementation. |

# Ecological Processes

## Central Valley Streamflows

**General Target:** The general target is to more closely approach the natural (unimpaired) seasonal Delta outflow patterns that:

- transport sediments,
- stimulate the estuary foodweb,
- provide for up and downstream fish passage,
- contribute to riparian vegetation succession,
- transport larval fish to the entrapment zone,
- maintain the entrapment zone and natural salinity gradient, and
- provide adequate attraction and migrating flows for salmon, steelhead, American shad, white sturgeon, green sturgeon, lamprey striped bass, splittail, delta smelt, and longfin smelt.

Besides seasonal peak flows, low and varying flows are also essential elements of the natural Delta outflow pattern to which native plant and animal species have adapted. Specific targets for different flow pattern attributes may vary with the different storage and conveyance alternatives being considered in the CALFED Program.

**TARGET 1:** Provide a March outflow that occurs from the natural late-winter and early-spring peak inflow from the Sacramento River. This outflow should be at least 20,000 cfs for 10 days in dry years, at least 30,000 cfs for 10 days in below-normal water years, and 40,000 cfs for 10 days in above-normal water years. Wet-year outflow is generally adequate under the present level of development (◆◆).

**PROGRAMMATIC ACTION 1A:** Prescribed outflows in March should be met by the cumulative flows of prescribed flows for the Sacramento, Feather, Yuba, and American rivers. Assurances must be obtained (e.g., to limit Delta diversions) that these prescribed flows will be allowed to contribute to Delta outflow. A portion of the inflow would be from base (minimum) flows from the east Delta tributaries and the San Joaquin River and its tributaries.

**TARGET 2:** Provide a late-April to early May outflow that emulates the spring inflow from the San Joaquin River. The outflow should be at least 20,000 cfs for 10 days in dry years, 30,000 cfs in below normal years, and 40,000 cfs in above normal years. These flows would be achieved through base flows from the Sacramento River and flow events from the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers (◆).

**PROGRAMMATIC ACTION 2A:** Prescribed outflows in late April and early May should be met by the cumulative prescribed flows from the Stanislaus, Tuolumne, and Merced rivers (see East San Joaquin Basin Ecological Management Zone), and Mokelumne and Calaveras rivers (see Eastside Delta Tributaries Ecological Management Zone). It will be necessary to obtain assurances that these prescribed flows are allowed to contribute to Delta outflow. The flow event would be made up of:

- the Cosumnes River,
- Mokelumne, Calaveras, and San Joaquin tributary pulsed flows prescribed under the May 1995 Water Quality Control Plan, and
- supplemental flows.

**TARGET 3:** Provide a fall or early winter outflow that approximates the first "winter" rain through the Delta (◆).

**PROGRAMMATIC ACTION 3A:** Allow the first "significant" fall/winter natural flow into the Delta (most likely either from rainfall or from unimpaired flows from tributaries and lower watersheds below storage reservoirs or from flows recommended by DFG and the Anadromous Fish Restoration Program [AFRP]) to pass through the Delta to the San Francisco Bay by limiting water diversions for up to 10 days. (No supplementary release of stored water from reservoirs would be required above that required to meet flows prescribed by DFG and AFRP.)

**TARGET 4:** Provide a minimum flow of 13,000 cfs on the Sacramento River below Sacramento in May of all but critical years (U.S. Fish and Wildlife Service 1995) (◆).

**PROGRAMMATIC ACTION 4A:** Supplement flows in May of all but critical years as needed from Shasta, Oroville, and Folsom reservoirs to maintain an inflow of 13,000 cfs to the Delta.

***RATIONALE:*** *Changing the seasonal pattern of freshwater flows into and through the Delta will help restore the Delta's ecosystem processes and functions. This ecosystem restoration is fundamental to the health of aquatic, wetland, and riparian resources.*

*Providing Delta outflow at the prescribed level in dry and normal years in March will provide the following benefits:*

- *improve survival of juvenile chinook salmon rearing in and passing downstream through the Delta,*

- *provide attraction flows to adult winter-run and spring-run chinook salmon, steelhead, striped bass, white and green sturgeon, splittail, and American shad migrating upstream through the Delta to spawning grounds in the Sacramento River and its tributaries,*

- *provide attraction flows for longfin and delta smelt moving upstream within the Delta to spawn in the Delta,*

- *provide downstream passage flows for steelhead, splittail, longfin smelt, and delta smelt to move through the Delta to the San Francisco Bay,*

- *help maintain lower water temperatures further into the spring to benefit adult and juvenile salmon, steelhead, longfin smelt, delta smelt, and splittail,*

- *stimulate the foodweb in the Delta and Bay,*

- *reduce potential effects of toxins released into Delta waters,*

- *promote growth of riparian vegetation along Delta waterways, and*

- *reduce loss of eggs, larvae, and juvenile fish into south Delta water diversions.*

*Supplementing an existing prescription for late April-early May pulse flow through the Delta from the San Joaquin River will assist juvenile San Joaquin chinook salmon and steelhead moving through the Delta to the Bay. The added flow will also help transport Delta and San Joaquin plankton and nutrients that have built up during the spring to the western Delta and Suisun Bay where they will stimulate the spring foodweb on which many of the important fish species living in the Delta depend. In addition, this flow will provide many of the same benefits described above for the March flow event. The flow event would be provided by supplementing the prescribed pulse flow in the 1995 Water Quality Control Plan with additional waters purchased from willing sellers on the Mokelumne, Stanislaus, Tuolumne, and Merced rivers.*

*Restoring the natural first "fall" flow through the Delta will provide the following benefits:*

- *support spring-run and other chinook salmon, steelhead, and American shad juveniles migrating from the mainstem rivers and tributaries in passing through the Delta to the Bay,*

- *provide attraction flows for adult fall-run and late-fall run chinook salmon, splittail, longfin smelt, delta smelt, and steelhead migrating upstream into or through the Delta, and*
- *reduce losses of migrating juvenile fish in south Delta pumping plants.*

*Maintaining a minimum inflow of 13,000 cfs from the Sacramento River in May will help maintain survival and transport of striped bass eggs and larvae, and white and green sturgeon from the Sacramento River above Sacramento into the Delta. This flow will also benefit remaining downstream migrating juvenile chinook salmon and steelhead from the Sacramento River and its tributaries, as well as upstream migrating winter- and spring-run chinook salmon and American shad. Supplemental average monthly storage releases of up to 2,500 cfs for 30 days (150,000 total acre-feet) may be necessary in dry years to meet this requirement. In normal and wet years, flows would generally exceed 13,000 cfs. Implementation of this action requires the development and application of an adaptive management program that includes development of testable hypothesis and implementation of a monitoring program to collect and analyze the data to evaluate the hypothesis.*

*Providing for larger flows during the seasons with when those flows occurred historically, particularly in normal or dry years, will help restore important ecological processes and* *functions that create and maintain habitat in the Delta. Delta channel maintenance, sediment and nutrient transport, and introductions of plant debris are some examples of processes improved by flow events. Spring flow events in dry and normal years will help sustain riparian and wetland vegetation.*

## COARSE SEDIMENT SUPPLY

**TARGET 1:** Maintain sediment supply to the Delta from upstream areas at levels needed to maintain existing habitats and to contribute to present and future efforts to reverse subsidence on Delta islands.

**PROGRAMMATIC ACTION 1A:** Develop a cooperative investigation to determine the existing sediment budget in the Delta based on sediment input, use within the Delta, and sediment output.

***RATIONALE:*** *Natural sediments of streams, rivers, and estuaries consist of mineral and organic silts, sands, gravel, cobble, and woody debris. These materials naturally enter, deposit, erode, and are transported through the Bay-Delta and its watershed. Sediment, like water, is one of the natural building blocks of the ecosystem. Many other ecological processes and functions, and habitats and species require specific types and amounts of sediment and the habitats sediments create.*

*Finer sediments are important in the natural development of riparian and wetland habitats. Major factors that influence the sediment supply in the Bay-Delta and its watersheds include many human activities such as dams, levees, and other structures, dredging, and gravel and sand mining.*

*River-transported sediments are an essential component of the physical structure and nutrient base of the Bay-Delta ecosystem and its riverine and tidal arteries. The size, volume, and seasonal timing of sediments entering the riverine and estuarine systems should be compatible with both natural and altered flow regimes. Sediment transport should match channel and floodplain characteristics of individual rivers, streams, and tidal sloughs. A specific sediment management objective is to redistribute sediment in the watersheds and valley components of the ecosystem. An appropriate level, rate, and size of sediment should be redistributed to match specific habitat requirements and ecological functions.*

## NATURAL FLOODPLAIN AND FLOOD PROCESSES

**TARGET 1:** Expand the floodplain area in the North, East, South, and Central and West Delta Ecological Management Units by putting approximately 10% of leveed lands into the active floodplain of the Delta (◆◆).

**PROGRAMMATIC ACTION 1A:** Convert leveed lands to tidal wetland/slough complexes in the North Delta Ecological Management Unit. Permanently convert island tracts (Little Holland, Liberty, and Prospect) at the south end of the Yolo Bypass to tidal wetland/slough complexes. Convert small tracts along Snodgrass Slough to tidal wetland/slough complexes. Construct setback levees along Minor, Steamboat, Oxford, and Elk Sloughs.

**PROGRAMMATIC ACTION 1B:** In the East Delta Ecological Management Unit, construct setback levees along the South Mokelumne River and connecting dead-end sloughs (Beaver, Hog, and Sycamore).

**PROGRAMMATIC ACTION 1C:** Remove levees that hinder tidal and floodflows in the headwater basins of east Delta dead-end sloughs (Beaver, Hog, and Sycamore) and allow these lands to be subject to flood overflow and tidal action.

**PROGRAMMATIC ACTION 1D:** Convert deeper subsided (sunken) lands between dead-end sloughs in the East Delta Ecological Management Unit east of the South Mokelumne River channel either to overflow basins and nontidal wetlands or to land designated for agricultural use.

**PROGRAMMATIC ACTION 1E:** Construct setback levees in the South Delta Ecological Management Unit along the San Joaquin River between Mossdale and Stockton.

**PROGRAMMATIC ACTION 1F:** Convert adjacent lands along the San Joaquin River between Mossdale and Stockton either to overflow basins and nontidal wetlands or to land designated for agricultural use.

**PROGRAMMATIC ACTION 1G:** Construct setback levees on corners of Delta islands along the San Joaquin River channel in the Central and West Delta Ecological Management Unit. Open leveed lands to tidal action where possible along the margins of the West Delta Ecological Management Unit.

***RATIONALE:*** *Subjecting approximately 10% of existing Delta leveed lands to tidal action and floodflows will greatly enhance the floodwater and sediment retention capacity of the Delta. The tracts at the south end of the Yolo Bypass, along the South Mokelumne River, and along the San Joaquin River channel are logical choices for this because they have limited levee systems and are already at high flood risk. These lands have had limited subsidence and offer good opportunities for restoring tidal wetland/slough complexes.*

*The other significant area for setbacks is along the main channel of the San Joaquin River. "Cutting corners" on some islands where the levee length to land area maintained is now high would reduce levee construction and maintenance.*

## CENTRAL VALLEY STREAM TEMPERATURES

**TARGET 1:** More frequently maintain daily water temperatures in the Delta channels below 60°F in the spring and 65°F in the fall to meet the temperature needs of salmon and steelhead migrating through or rearing in the Delta (◆).

**PROGRAMMATIC ACTION 1A:** Improve riparian woodland habitats along migrating channels and sloughs of the Delta.

**PROGRAMMATIC ACTION 1B:** Improve SRA habitat along migration routes in Delta.

***RATIONALE:*** *Maintaining water temperatures of less than 60 °F in the spring and 65 °F in the fall can improve survival of juvenile chinook salmon rearing in or migrating through the Delta. Maintaining maximum daily water temperatures in the channels and sloughs of the Sacramento-San Joaquin Delta Ecological Management Zone of less than 66 °F in the fall will ensure healthy conditions for upstream migrating adult chinook salmon and early emigrating juveniles. Improved riparian habitat along Delta channels and the spring flow events should maintain cooler spring temperatures in dry and normal years. Improved riparian and SRA habitat will help to maintain lower Delta water temperatures from spring through fall.*

## DELTA CHANNEL HYDRAULICS

**TARGET 1:** Reestablish more natural internal Delta water flows in channels (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Reduce velocities in selected Delta channels by increasing cross-sectional areas of channel by means of setback levees or by constricting flows into and out of the channels.

**PROGRAMMATIC ACTION 1B:** Increase tidal flow and cross-Delta transfer of water to south Delta pumping plants to selected channels to lessen flow through other channels.

**PROGRAMMATIC ACTION 1C:** Manage the operation of existing physical barriers so that resulting hydraulics upstream and downstream of the barrier are more like levels in the mid-1960s.

**PROGRAMMATIC ACTION 1D:** Close the DCC when opportunities allow, as specified in the 1995

Water Quality Control Plan and recommended by the U.S. Fish and Wildlife Service (1995), in the period from November through January when appropriate conditions trigger closure (i.e., internal Delta exports are occurring).

**TARGET 2:** Restore hydrodynamic conditions in the rivers and sloughs of the Delta sufficient to support targets for the restoration of aquatic resources (◆◆).

**PROGRAMMATIC ACTION 2A:** Restore 3,000 to 4,000 acres of tidal perennial aquatic habitat and 20,000 to 25,000 acres of tidally influenced freshwater marsh. *(Note: These recommendations are contained within programmatic actions presented in this section for tidal perennial aquatic habitat and fresh emergent wetland (tidal) and are not additions to acreages presented in the targets and programmatic actions for habitat.)*

**TARGET 3:** Maintain net downstream flows in the mainstem San Joaquin River from Vernalis to immediately west of Stockton from September through November to help sustain dissolved oxygen levels and water temperatures adequate for upstream migrating adult fall-run chinook salmon (◆◆).

**PROGRAMMATIC ACTION 3A:** Operate a barrier at the head of Old River from August through November.

**TARGET 4:** Restore 50 to 100 miles of tidal channels in the southern Yolo Bypass within the north Delta, while maintaining or improving the flood carrying capacity of the Yolo Bypass (◆). *(Note: This target is in addition to targets and programmatic actions presented in the Delta Slough habitat section.)*

**PROGRAMMATIC ACTION 4A:** Construct a network of channels within the Yolo Bypass to connect the Putah and Cache Creek sinks, and potentially the Colusa drain, to the Delta. These channels should effectively drain all flooded lands in the bypass after floodflows stop entering the bypass from the Fremont and Sacramento weirs. The channels would maintain a base flow through the spring to allow juvenile anadromous and resident fish to move from rearing and migratory areas.

**PROGRAMMATIC ACTION 4B:** Reduce flow constrictions in the Yolo Bypass such as those in the openings in the railway causeway that parallels Interstate 80.

***RATIONALE:*** *Internal Delta hydraulics have been highly modified since the early 1950s. Adverse hydraulic action has created poor conditions for sustaining spawning, rearing, and foodweb production in the Delta and for the transport of larval fish such as delta smelt and striped bass; (U.S. Fish and Wildlife Service 1994 Delta Smelt Biological Opinion; U.S. Fish and Wildlife Service 1995 Delta Smelt Opinion on the 1995 Water Quality Control Plan; U.S. Fish and Wildlife Service 1995; Independent Scientific Group 1996).*

*Restoring hydraulic conditions within the Delta by modifying physical barriers in the Delta will support natural transport functions, reduce entrainment (in diversions) into parts of the Delta where survival is low, and assist in transporting juvenile fish into and through the Delta to highly productive nursery areas in the western Delta and Suisun Bay. Modifying DCC operation will restore historical hydraulic conditions in lower Mokelumne channels of the north Delta (U.S. Fish and Wildlife Service 1994 Delta Smelt Biological Opinion; U.S. Fish and Wildlife Service 1995 Delta Smelt Opinion on the 1995 Water Quality Control Plan; U.S. Fish and Wildlife Service 1995). Internal Delta hydraulics can be improved through several operational or structural approaches. The removal of structural barriers that alter internal Delta hydraulic patterns may be possible, depending on which alternative is selected.*

*Maintaining adequate flows past Stockton will improve existing harmful conditions of low* *dissolved oxygen and high water temperatures that can hinder the upstream movement of adult San Joaquin fall-run chinook salmon. In addition, improved flows past Stockton will reduce straying of adult salmon into Central and South Delta channels (California Department of Fish and Game 1972).*

*Improving the channel network in the Yolo Bypass will improve the migration pathway for salmon produced in Putah and Cache creeks, as well as for upper Sacramento River salmon using the Yolo Bypass as a pathway to the Delta. A well-drained system with permanent sloughs will keep juvenile salmon from being stranded in the bypass when flows stop. Permanent sloughs will provide valuable juvenile salmon rearing habitat in late winter and early spring.*

*Improving habitats along riparian corridors in the Yolo Bypass will provide additional spawning and rearing habitat for splittail and rearing and migration habitat for juvenile chinook salmon and perhaps for delta smelt and other native resident fishes. Conditions will also improve for wildlife and waterfowl.*

*Restoring connections among Delta channels, freshwater marsh, and seasonal wetland habitats will enhance habitat conditions for special-status species such as the splittail. Restoring this habitat connectivity in a large-scale mosaic in the North Delta will help restore the ecosystem processes and functions fundamental to supporting the foodweb and will improve conditions for rearing chinook salmon, steelhead, sturgeon, juvenile delta smelt, striped bass, and splittail (Fahrig and Merriam 1985).*

### BAY-DELTA AQUATIC FOODWEB

**TARGET 1:** Increase primary and secondary nutrient productivity in the Delta to levels historically observed in the 1960s and early 1970s (◆).

**PROGRAMMATIC ACTION 1A:** Actions described above to restore streamflow, floodplain flooding, Delta hydraulics, tidal wetlands and sloughs, and riparian habitat would increase primary and secondary productivity in the Delta. Relocating the intake of the South Delta pumping plants to the North Delta would also increase Delta productivity.

***RATIONALE:*** *Increasing the area of tidal wetland/slough habitat and the residence time of Delta waters will increase primary and secondary productivity. More flooding of floodplains will provide more nutrients and organic carbon inputs to Delta waters. Relocating the intakes of the South Delta pumping plants will increase the residence time of Central and South Delta waters and allow more of the highly productive San Joaquin waters to be retained in the Delta.*

## HABITATS

### GENERAL RATIONALE

*Restoring wetland and riparian habitats along with tidal perennial aquatic habitats is an essential element of the restoration strategy for the Sacramento-San Joaquin Delta Ecological Management Zone. The general approach for habitat restoration is to mimic to the extent feasible a well-connected mosaic of aquatic and riparian habitats. In some areas, these habitat should be a contiguous as possible avoiding small habitat patches in favor of larger. Habitat corridors in the Delta should be emphasized that interconnect with habitat corridors on the main stem Sacramento and San Joaquin rivers as well as the eastside tributaries such as the Mokelumne River.*

*The extent and distribution of the land-water interface (contact) between aquatic habitats and interconnected wetland and riparian habitats have been altered since the mid-1850s by Delta reclamation. Since 1906, the amount of land-water interface has been reduced 32% in the East Delta Ecological Management Unit, 25% in the*

*South Delta Ecological Management Unit, and 45% in the Central and West Delta Ecological Management Unit.*

*Increasing the ratio of land-water interface and increasing the shoreline perimeter will help restore a complex habitat mosaic on a large scale in the Delta. This will support essential ecosystem processes and functions. These measures are also fundamental to supporting the foodweb and improving conditions for rearing chinook salmon, steelhead, sturgeon, delta smelt, striped bass, and splittail. Foodweb support functions for wildlife will also benefit (Cummins 1974; Clark 1992).*

*Restoring high-quality freshwater marsh and brackish water marsh, both seasonal and permanent, will increase the production and availability of natural forage for waterfowl and other wildlife. This restoration will also increase the overwinter survival rates of wildlife that winter in this Ecological Management Zone and will strengthen them for migration, thus improving their breeding success. Expanding these habitats will also reduce the amount and concentrations of contaminants that could, upon entering the Delta's sloughs, damage the health of the aquatic resources.*

*The restoration of all habitats will be within the structure of adaptive management. The program will move forward in a step-wise progression. Each element will be designed with a testable hypothesis and a monitoring program to collect the scientific data needed to evaluate the hypothesis will be in place. Implementation will begin on a small scale and depending on the monitoring results will either continue or be modified based on results of completed projects.*

## TIDAL PERENNIAL AQUATIC HABITAT

**TARGET 1:** Restore 1,500 acres of shallow-water habitat in the North Delta Ecological Management Unit; 1,000 acres of shallow-water habitat in the East Delta Ecological Management Unit; 2,000 acres of shallow-water habitat in the South Delta Ecological Management Unit; and 2,500 acres of shallow-water habitat in the Central and West Delta Ecological Management Unit (◆◆).

**PROGRAMMATIC ACTION 1A:** Restore 500 acres of shallow-water habitat at Prospect Island in the North Delta Ecological Management Unit.

**PROGRAMMATIC ACTION 1B:** Restore 1,000 acres of shallow-water habitat in the downstream (south) end of the Yolo Bypass (Little Holland and Liberty islands) within the North Delta Ecological Management Unit.

**PROGRAMMATIC ACTION 1C:** Restore 1,000 acres of shallow-water habitat at the eastern edge of the East Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level.

**PROGRAMMATIC ACTION 1D:** Restore 2,000 acres of shallow-water habitat at the south and eastern edge of the South Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level.

**PROGRAMMATIC ACTION 1E:** Restore 2,500 acres of shallow-water habitat in the Central and West Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level. A program of fill placement or longer-term subsidence reversal may be needed to accomplish this action.

**PROGRAMMATIC ACTION 1F:** Restore Frank's Tract to a mosaic of habitats using clean dredge materials and natural sediment accretion.

**TARGET 2:** Restore 500 acres of shoals in the westernmost portion of the Central and West Delta (◆◆).

**PROGRAMMATIC ACTION 2A:** Implement a sediment management program that results in deposition and accretion within portions of Central and West Delta channels and bays, forming 500 acres of shallow shoal habitat restored to tidal influence.

***RATIONALE:*** *Restoring, improving, and protecting high-quality shallow-water habitat will provide greater foraging areas for rearing juvenile fish and waterfowl in this Ecological Management Zone. These areas typically provide high primary and secondary productivity and support nutrient cycling that sustains good forage. These areas also provide good forage for waterfowl that use underwater vegetation growing in the shoals and for diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984; Shloss 1991; Sweetnam and Stevens 1993; San Francisco Estuary Project 1992a; U.S. Fish and Wildlife Service 1996; Lindberg and Marzuola 1993).*

*Restoring, improving, and protecting high-quality shallow shoal habitat will provide foraging habitat for rearing juvenile fish. These areas typically provide high primary and secondary productivity and support nutrient cycling that sustains good forage. These areas also provide good forage for shorebirds that feed on invertebrates, waterfowl that use underwater vegetation growing in the shoals, and diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984).*

*Franks's Tract is a flooded Delta island that can be restored to a mosaic of habitat types with no impact to agriculture. Frank's Tract levees were breached and the island has been flooded since the early 1900s. The deep bed of the island does not provide good quality habitat for native fishes. Parts of the island could be elevated through a combination of dredge material placement, natural sediment accretion, and peat accumulation. Frank's Tract will be a functional component of the San Joaquin River corridor, a major fish rearing and migration area, as well as providing continuity with existing and other proposed habitats in the Central and West Delta Ecological Management Unit. Developing the tract must also occur in conjunction with the control or eradication of introduced, nuisance aquatic plants for restoration to be most beneficial to native species.*

## NONTIDAL PERENNIAL AQUATIC HABITAT

**TARGET 1:** Develop 500 acres of deep open-water areas (more than 4 to 6 feet deep) within restored fresh emergent wetlands in the Delta to provide resting habitat for water birds, foraging habitat for diving ducks and other water birds and semi-aquatic mammals that feed in deep water, and habitat for associated resident pond fish species (◆).

**PROGRAMMATIC ACTION 1A:** Develop 100 acres of open-water areas within restored fresh emergent wetland habitats in the West and Central Delta Ecological Management Unit such as on Twitchell or Sherman islands.

**PROGRAMMATIC ACTION 1B:** Develop 200 acres of open-water areas within restored fresh emergent wetland habitats in the East Delta Ecological Management Unit.

**PROGRAMMATIC ACTION 1C:** Develop 200 acres of open-water areas within restored fresh emergent wetland habitats in the South Delta Ecological Management Unit.

**TARGET 2:** Develop 2,100 acres of shallow, open-water areas (less than 4 to 6 feet deep) in restored fresh emergent wetland habitat areas in the Delta to provide resting, foraging, and brood habitat for water birds and habitat for fish and aquatic plants and semi-aquatic animals (◆◆).

**PROGRAMMATIC ACTION 2A:** Develop 500 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the Central and West Delta Ecological Management Unit such as on Twitchell or Sherman Islands.

**PROGRAMMATIC ACTION 2B:** Develop 300 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the East Delta Ecological Management Unit.

**PROGRAMMATIC ACTION 2C:** Develop 300 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the South Delta Ecological Management Unit.

**PROGRAMMATIC ACTION 2D:** Develop 1,000 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the North Delta Ecological Management Unit.

***RATIONALE:*** *Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife such as river otter will increase their over-winter survival rate. Other water-associated wildlife will also benefit (Madrone and Associates 1980).*

*Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife such as river otter will increase their over-winter survival rates. Other water-associated wildlife will also benefit (Madrone and Associates 1980).*

*Implementation of actions designed to increase or improve acreages of nontidal perennial aquatic habitats need to develop or integrate subsidence reversal and sediment accretion. These will assist in raising bottom elevations to levels that can support rooted submergent and emergent vegetation.*

### DELTA SLOUGHS

**TARGET 1:** Restore ecological structure and functions of the Delta waterways network by increasing the land-water interface ratio a minimum of 50% to 75% compared to 1906 conditions and by restoring 100 to 150 miles of small distributary sloughs (less than 50 to 75 feet wide) hydrologically connected to larger Delta channels (◆◆). *(Note: This target is in addition to the Delta slough target presented in the target section for Delta Channel Hydraulics.)*

**PROGRAMMATIC ACTION 1A:** To replace lost slough habitat and provide high-quality habitat areas for fish and associated wildlife, the short-term solution for the Central and West Delta Ecological Management Unit is to restore 20 miles of slough habitat. The long-term solution is to restore 50 miles of slough habitat. In both the North Delta and East Delta Ecological Management Units, the short-term solution is to restore 10 miles of slough habitat. The long-term solution is to restore 30 miles of slough habitat. In the South Delta Ecological Management Unit, the short-term solution is to restore 25 miles of slough habitat and the long-term solution is to restore 50 miles of slough habitat.

**PROGRAMMATIC ACTION 1B:** Restore tidal action to portions of islands and tracts in the North and East Delta Ecological Management Units with appropriate elevation, topography, and water-landform conditions. This will sustain tidally influenced freshwater marshes with 20 to 30 linear miles of narrow, serpentine-shaped sloughs within the wetlands and floodplain.

***RATIONALE:*** *Restoring, improving, and protecting sloughs in the Ecological Management Units of the Sacramento-San Joaquin Delta Ecological Management Zone will help sustain high-quality shallow-water habitat for spawning of native fish and for foraging of juvenile fish. Restoring small dead-end sloughs and tidally influenced freshwater marshes and mudflats in the Sacramento-San Joaquin Delta Ecological Management Zone will provide habitat for spawning of native fish and for foraging of juvenile fish, increase production of primary and secondary food species, and support nutrient cycling that sustains quality forage. These sloughs can also provide loafing sites for waterfowl and habitat for the western pond turtle (Simenstad et al. 1992 and 1993; Lindberg and Marzuola 1993; Madrone and Associates 1980).*

*Land-water interface targets represent a reasonable level necessary to restore Bay-Delta ecosystem functions and overall health by* *increasing water-to-perimeter shoreline ratios and patterns to those of the early 1900s. Delta slough habitat will be restored as a mosaic of habitats including slough, tidal perennial, and tidal emergent habitats.*

### MIDCHANNEL ISLANDS AND SHOALS

**TARGET 1:** Maintain existing channel islands and restore 50 to 200 acres of high-value islands in selected sloughs and channels in each of the Delta's Ecological Management Units (◆◆).

**PROGRAMMATIC ACTION 1A:** Actively protect and improve existing channel islands in the Delta.

**PROGRAMMATIC ACTION 1B:** Restore 50 to 200 acres of channel islands in the Delta where channel islands once existed.

***RATIONALE:*** *Many of the remnant channel or "berm" islands in the Delta have been lost to continuing erosion and degradation. Restoring, improving, and protecting the riverine-edge habitat of these islands will provide habitat for juvenile salmon rearing in this Ecological Management Zone. Terrestrial vertebrates that will receive indirect benefits include the western pond turtle and shorebirds and wading birds (Fris and DeHaven 1993; Mahoney and Ermin 1984; Knight and Bottorf 1983; Knox 1984; Novick and Hein 1982; Moore and Gregory 1988; May and Levin 1991; Levin et al. 1995).*

*Restoring, improving, and protecting high-quality shallow habitat will provide forage for rearing juvenile fish. These habitats typically provide high levels of primary (plant) and secondary (animal) productivity and support nutrient cycling functions that can sustain quality forage. These habitats also provide high-quality forage habitat for waterfowl who use submergent vegetation growing in the shoals and diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984). Restoring high-quality brackish tidal marshes on and adjacent to these islands will contribute to cycling nutrients, maintaining the foodweb, and increasing production of primary and secondary food species in a geographic location already noted for its value as a rearing habitat for estuarine fish. Several plant species of special concern such as the Suisun aster will benefit from increasing the area of brackish tidal marsh in the Delta (Landin and Newling 1988; Dionne et al. 1994; Lindberg and Marzuola 1993).*

### FRESH EMERGENT WETLAND HABITAT (TIDAL)

**TARGET 1:** Increase existing tidal freshwater marsh habitat in the Delta by restoring 30,000 to 45,000 acres of lands designated for floodplain restoration (◆◆).

**PROGRAMMATIC ACTION 1A:** Develop tidal freshwater marshes in the North Delta Ecological Management Unit.

**PROGRAMMATIC ACTION 1B:** Develop tidal freshwater marshes on small tracts of converted leveed lands along Snodgrass Slough.

**PROGRAMMATIC ACTION 1C:** Develop tidal freshwater marshes along the upper ends of dead-end sloughs in the east Delta.

**PROGRAMMATIC ACTION 1D:** Develop tidal freshwater marshes along all setback levees and levees with restored riparian habitat.

**PROGRAMMATIC ACTION 1E:** Develop tidal freshwater marshes on restored channel island habitat. *(Note: Any tidal freshwater marsh habitat developed is included in Target 1 for this habitat type.)*

***RATIONALE:*** *Restoring tidally influenced freshwater marshes in the Sacramento-San Joaquin Delta Ecological Management Zone will increase production of primary and secondary food species and support nutrient cycling* *functions that can sustain quality forage conditions for fish, waterfowl, shorebirds, and wildlife (Lindberg and Marzuola 1993; Miller 1993; Simenstad et al. 1992 and 1993). Increasing the area of freshwater tidal marshes in each of the four Delta Ecological Management Units will help support the proper aquatic habitat for rearing and outmigrating juvenile chinook salmon, steelhead, and sturgeon and for rearing delta smelt, striped bass, and splittail. Restoring high-quality freshwater marshes, both tidal and nontidal, will contribute to nutrient cycling, maintaining the foodweb, and increased production of primary and secondary food species. In addition, increasing the area of freshwater marsh will contribute to an ecosystem that can accommodate sea level rise. This can only be effective, however, if upland migration corridors are available for the marshes to expand as sea level rises.*

*The targets selected take into account the large losses of tidal freshwater marshes since the early 1900s. The Sacramento-San Joaquin Delta Ecological Management Zone lost nearly 90,000 acres, with the greatest losses in the North Delta and Central and West Delta Ecological Management Units. Acreage changes in the South Delta were insignificant during that period because most losses these occurred before 1900. Restoration targets are to restore between 30% and 50% of the losses since 1900. The level of restoration was increased in the South Delta because of the prior losses documented by Landin and Newling (1988). There was a substantial loss of fresh emergent wetlands in the South Delta Ecological Management Unit prior to the 1900s and a significant amount of wetlands could be restored in this unit depending on which alternative is selected.*

## FRESH EMERGENT WETLAND HABITAT (NONTIDAL)

**TARGET 1:** Restore a total of 3,000 acres of nontidal freshwater marshes in the North and the East Delta Ecological Management Units; restore 4,000 acres of nontidal fresh emergent wetland in the South Delta Ecological Management Unit as part of a subsidence control program; and restore 10,000 acres of nontidal fresh emergent wetland in the Central and West Delta Ecological Management Unit as part of a subsidence control program (◆◆).

**PROGRAMMATIC ACTION 1A:** Restore 1,000 acres of nontidal freshwater marshes on Twitchell Island.

**PROGRAMMATIC ACTION 1B:** Restore 1,000 acres of nontidal freshwater marshes in the Yolo Bypass.

**PROGRAMMATIC ACTION 1C:** Restore 1,000 acres of nontidal freshwater marshes in leveed lands designated for floodplain overflow adjacent to the dead-end sloughs in the East Delta Ecological Management Unit.

**PROGRAMMATIC ACTION 1D:** Restore 4,000 acres of nontidal freshwater marshes in the South Delta in lands designated for floodplain overflow.

**PROGRAMMATIC ACTION 1E:** Restore 10,000 acres of nontidal freshwater marshes on Delta Islands of the Central and West Delta Ecological Management Unit. *(Note: Up to 75% of this acreage may be restored to tidal actions after the appropriate land elevations are achieved through island accretion. Upon restoring tidal action, targets for the Central and West Delta Ecological Management Unit would be adjusted to avoid the need to restore additional non-tidal wetland above 2,500 acres.)*

***RATIONALE:*** *The restoration of high-quality nontidal freshwater marshes will contribute to nutrient cycling, maintaining the foodweb, and supporting enhanced levels of primary and secondary food production. Increasing the areal extent of nontidal freshwater marsh in the Delta, particularly in the Central and West Delta Ecological Management Unit, will be an important component of subsidence control and island accretion. Permanent freshwater marsh can* *help arrest and in some cases reverse subsidence where peat oxidation has resulted in land elevations more than 15 feet below sea level. Increasing the area of freshwater marsh will contribute to an ecosystem that can accommodate sea level rise. Habitats for wetland wildlife will be improved. The targets selected take into account the large losses of nontidal freshwater marshes since the early 1900s. The Sacramento-San Joaquin Delta Ecological Management Zone lost nearly 90,000 acres with the greatest losses in the North Delta and Central and West Delta Ecological Management Units. Acreage changes in the South Delta were insignificant during that period because most losses there occurred before 1900.*

## SEASONAL WETLAND HABITAT

**TARGET 1:** Restore and manage at least 4,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the North Delta Ecological Management Unit (◆◆).

**PROGRAMMATIC ACTION 1A:** Improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the Yolo Bypass.

**PROGRAMMATIC ACTION 1B:** Restore and manage 2,000 acres of additional seasonal wetland habitat in association with the Yolo Basin Wildlife Area.

**TARGET 2:** Restore and manage at least 6,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the East Delta Ecological Management Unit (◆◆).

**PROGRAMMATIC ACTION 2A:** Develop a cooperative program to restore and manage 1,000 acres of additional seasonal wetland habitat on Canal Ranch.

**PROGRAMMATIC ACTION 2B:** Develop a cooperative program to restore and manage 5,000 acres of additional seasonal wetland habitat.

**PROGRAMMATIC ACTION 2C:** Improve management of 1,000 acres of existing degraded seasonal wetland habitat.

**TARGET 3:** Restore and manage at least 8,000 acres of additional seasonal wetland habitat and improve management of 1,500 acres of existing, degraded seasonal wetland habitat in the Central and West Delta Ecological Management Unit (◆◆).

**PROGRAMMATIC ACTION 3A:** Restore and manage 4,000 acres of additional seasonal wetland habitat on Twitchell Island.

**PROGRAMMATIC ACTION 3B:** Restore and manage 4,000 acres of additional seasonal wetland habitat on Sherman Island.

**PROGRAMMATIC ACTION 3C:** Develop a cooperative program to improve management of 1,500 acres of existing degraded seasonal wetland habitat.

**TARGET 4:** Restore and manage at least 12,000 acres of additional seasonal wetland habitat and improve management of 500 acres of existing, degraded seasonal wetland habitat in the South Delta Ecological Management Unit (◆◆).

**PROGRAMMATIC ACTION 4A:** Develop a cooperative program to restore and manage 12,000 acres of additional seasonal wetland habitat.

**PROGRAMMATIC ACTION 4B:** Develop a cooperative program to improve management of 500 acres of existing degraded seasonal wetland habitat.

***RATIONALE:*** *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the* *restoration strategy for the Sacramento-San Joaquin Delta Ecological Management Zone. Restoring the ratio of land-water interface will help restore a mosaic of complex habitats that will restore important ecosystem processes and functions. Restoring these habitats will also reduce the amount and concentrations of contaminants that could, once they enter the Delta's sloughs, interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

*Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions for the Delta aquatic zone, significant areas of restored seasonal wetlands in the Sacramento-San Joaquin Delta Ecological Management Zone should be subject to periodic flooding and overland flow from Delta and river floodplains.*

## RIPARIAN AND RIVERINE AQUATIC HABITATS

**TARGET 1:** Restore 10 to 20 linear miles of riparian and riverine aquatic habitat along the San Joaquin River in the South Delta Ecological Management Unit to create corridors of riparian vegetation of which 50% is to be over 75 feet wide and 40% is to be no less than 300 feet wide and 1 mile long (◆◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to restore riparian habitat either by obtaining conservation easements or by purchase from willing sellers.

**TARGET 2:** Restore 15 to 25 linear miles of riparian and riverine aquatic habitat along other Delta island levees throughout the South Delta Ecological Management Unit. This will create riparian vegetation corridors of which 60% is to be more than 75 feet wide and 10%, no less than 300 feet wide and 1 mile long (◆◆).

**PROGRAMMATIC ACTION 2A:** Develop a cooperative program to restore riparian habitat either by obtaining conservation easements or by purchase from willing sellers.

**TARGET 3:** Restore 10 to 15 linear miles of riparian and riverine aquatic habitat along the Sacramento River below Sacramento of which 40% is to be more than 75 feet wide and 20% over 300 feet wide (◆).

**PROGRAMMATIC ACTION 3A:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore 10 to 15 linear miles of riparian habitat along the Sacramento River in the North Delta Ecological Management Unit. Obtain conservation easements for, or purchase from willing sellers, land needed to create corridors of riparian vegetation.

**TARGET 4:** Restore 8 to 15 linear miles of riparian and riverine aquatic habitat in the East Delta Ecological Management Unit of which 40% is to be more than 75 feet wide and 20% over 300 feet wide (◆◆).

**PROGRAMMATIC ACTION 4A:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore 5 to 10 linear miles along the Mokelumne River and 3 to 5 miles along the Cosumnes River in the East Delta Ecological Management Unit to create corridors of riparian vegetation.

**TARGET 5:** Restore 10 to 20 linear miles of riparian and riverine aquatic habitat in the North Delta Ecological Management Unit of which 40% is to be more than 75 feet wide and 20% over 300 feet wide (◆◆).

**PROGRAMMATIC ACTION 5A:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore 5 to 10 linear miles along the Steamboat Slough as part of the development of a North Delta Habitat Corridor.

**TARGET 6:** Restore or plant riparian and riverine aquatic habitats and recreate slough habitat and set back levees (◆).

**PROGRAMMATIC ACTION 6A:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore riparian habitat along newly created sloughs and sloughs with new levee setbacks.

**PROGRAMMATIC ACTION 6B:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore riparian habitat along new or upgraded Delta levees.

**TARGET 7:** Protect existing riparian woodlands in North, East, and South Delta Ecological Management Units (◆◆).

**PROGRAMMATIC ACTION 7A:** Expand the Stone Lakes and Cosumnes River Preserves from their current size by an additional 500 acres of existing woodland habitat. Share costs with the Nature Conservancy to acquire in-fee title to the lands needed from willing landowners.

**PROGRAMMATIC ACTION 7B:** Purchase riparian woodland property or easements.

***RATIONALE:*** *Many species of wildlife, including several species listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the Central Valley are dependent on or closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than any other habitat type in California. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support.*

*Restoring, improving, and protecting high-quality riparian woodland habitat will enhance nutrient cycling and foodweb support and provide habitat for terrestrial invertebrates that will sustain resident fish and rearing juvenile anadromous fish in the Delta. Terrestrial vertebrates that will benefit include the Swainson's hawk, western yellow-billed cuckoo, wading birds, neotropical birds, and the riparian brush rabbit. This habitat will also increase suitable habitat for wildlife such as the western pond turtle and wood duck (Bjornn et al. 1991; Shields et al. 1993; Jensen et al. 1987; Fris and DeHaven 1993; Mahoney and Erman 1984; Knight and Bottorff 1983).*

*Large-scale riparian restoration projects are needed to restore the biodiversity (variety of species) and the sustainability and resilience of these habitats. This is consistent with the recommended strategy for restoration of rivers and aquatic ecosystems on a large landscape scale (National Research Council 1992; Noss and Harris 1986; Hutto et al. 1987; Scott et al. 1987; Noss et al. 1994). Large-scale restoration of broad, diverse riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will support increased nesting populations of Swainson's hawks and other raptors, as well as the yellow-billed cuckoo. Wood ducks will also benefit from increases in riparian habitat. Heron and egret rookeries will increase as well (Baltz and Moyle 1984; Hudson 1991; Motroni 1981; National Resource Council 1992; Gaines 1974 and 1977).*

*Riparian woodland habitats are important habitat use areas for many species of wildlife in the Central Valley. The loss or degradation of historic stands of riparian woodland has substantially reduced the habitat area available for associated wildlife. Such woodlands will also contribute to the recovery of species such as Swainson's hawk. Actions to restore ecological processes and functions, increase and improve habitats, and* *reduce stressors are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late-fall-run chinook salmon; splittail; and delta smelt. These actions will also benefit the Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake.*

## INLAND DUNE SCRUB

**TARGET 1:** Enhance 50 to 100 acres of low- to moderate-quality Antioch inland dune scrub habitat in the Delta to provide high-quality habitat for special-status plant and animal species and associated wildlife (◆◆).

**PROGRAMMATIC ACTION 1A:** Support programs for protecting and restoring inland dune scrub habitat at existing ecological preserves in the Central and West Delta Ecological Management Unit.

**PROGRAMMATIC ACTION 1B:** Protect and restore inland dune scrub habitat areas adjacent to existing ecological preserves in the Central and West Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

***RATIONALE:*** *An analysis of soils indicated that the historical extent of inland sand dunes in the Delta was probably less than 10,000 acres. The extent and habitat quality of inland dune scrub has declined as a result of recent land use changes. Inland dune scrub is a unique Delta community and supports several special-status plant and animal species, including the Lange's metalmark, which is federally listed as endangered. Protection and restoration of inland dune scrub habitat will help maintain existing special-status species and assist in recovery of their populations.*

## FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

**TARGET 1:** Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

**PROGRAMMATIC ACTIONS:** No additional programmatic actions are recommended.

***RATIONALE:*** *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Delta ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of rivers and streams and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

## PERENNIAL GRASSLAND

**TARGET 1:** Restore 4,000 to 6,000 acres of perennial grasses in the North, East, South, and Central and West Delta Ecological Management Units associated with existing or proposed wetlands and floodplain habitats (◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to restore 1,000 acres of perennial grassland in the North Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

**PROGRAMMATIC ACTION 1B:** Develop a cooperative program to restore 1,000 acres of perennial grassland in the East Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

**PROGRAMMATIC ACTION 1C:** Develop a cooperative program to restore 1,000 to 2,000 acres of perennial grassland in the South Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

**PROGRAMMATIC ACTION 1D:** Develop a cooperative program to restore 1,000 to 2,000 acres of perennial grassland in the Central and West Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

***RATIONALE:*** *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential element of the restoration strategy for this Ecological Management Zone. Eliminating fragmentation and restoring connection of habitats will enhance habitat conditions for special-status species such as the California black rail and foraging habitat for Swainson's hawk. For instance, the habitats for these species have been degraded by a loss of the adjacent escape cover needed during periods of high flows or high tides.*

## AGRICULTURAL LANDS

**TARGET 1:** Cooperatively manage 40,000 to 75,000 acres of agricultural lands (◆◆).

**PROGRAMMATIC ACTION 1A:** Increase the area of Delta corn fields and pastures flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

**PROGRAMMATIC ACTION 1B:** Periodically flood pasture from October through March in portions of the Delta relatively free of human disturbance to create suitable roosting habitat for wintering greater sandhill crane, and for other wintering sandhill crane subspecies.

**PROGRAMMATIC ACTION 1C:** Create permanent or semipermanent ponds in Delta farm areas that provide suitable waterfowl nesting habitat but lack suitable brooding habitat, to increase resident dabbling duck production.

**PROGRAMMATIC ACTION 1D:** Increase the acreage farmed for wheat and other crops that provide suitable nesting habitat for waterfowl and other ground-nesting species in the Delta.

**PROGRAMMATIC ACTION 1E:** Convert agricultural lands in the Delta from crop types of low forage value for wintering waterfowl, wintering sandhill cranes, and other wildlife to crop types of greater forage value.

**PROGRAMMATIC ACTION 1F:** Defer fall tillage on corn fields in the Delta to increase the forage for wintering waterfowl, wintering sandhill cranes, and associated wildlife.

**PROGRAMMATIC ACTION 1G:** Develop a cooperative program to improve management on 8,000 acres of Delta corn and wheat fields and to reimburse farmers for leaving a portion of the crop in each field unharvested as forage for waterfowl, sandhill cranes, and other wildlife.

***RATIONALE:*** *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed, salinity, and pest control; stubble management; and tailwater circulation ponds.*

*Reducing the entrainment of lower trophic organisms (food species) such as phytoplankton and zooplankton, and of life stages of higher trophic organisms such as fish eggs, larvae, and juveniles into agricultural and export water diversions will increase production of primary and secondary food species. This will also support nutrient cycling functions that can sustain quality forage for aquatic resources in and dependent on the Delta (Chadwick 1974).*

*Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980; Fredrickson and Reid 1988; Schultz 1990; and, Ringelman 1990).*

*Restoring roosting habitat in this Ecological Management Zone, especially when it is near forage habitat, will increase the overwinter survival of sandhill cranes and strengthen them for migration, thus improving breeding success. Decreasing in human disturbance in the roosting sites will also improve the health of the crane in the Delta. Actions to restore ecological processes and functions, increase and improve habitats, and reduce stressors are prescribed primarily to increase populations of lower level food species, aquatic and terrestrial invertebrates, and forage fish such as threadfin shad. Improving the foodweb of the Delta will help restore the health of the Bay-Delta's aquatic ecosystem.*

*Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the red-legged frog, tiger salamander, giant garter snake, and western pond turtle will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground-nesting birds.*

*Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980; Fredrickson and Reid 1988; Schultz 1990; and Ringelman 1990). Following the extensive loss of native upland habitats, upland wildlife species have adapted to the artificial upland environment of some agricultural land uses and have become dependent on agricultural upland areas and field-border shelter belts to sustain their populations.*

*Habitat restoration will occur over a 30 year period. Initial efforts will be directed at lands presently in State or Federal ownership. Restoration will be strictly guided by adaptive management in which conceptual ecosystem models and hypotheses will be developed. Small projects will be implemented to test the hypotheses regarding habitat restoration. For example, one hypothesis might be that delta smelt will occupy tidal perennial aquatic habitat for foraging, spawning, and rearing. Monitoring will determine it the hypothesis is true or false (e.g., do delta smelt use restored habitat). Based on the results of monitoring under the adaptive management program, an evaluation will be made regarding the need and benefit of restoring additional acres of tidal perennial aquatic habitat.*

*The Delta Protection Commission suggested (letter to CALFED dated July 10, 1998) some alternatives for meeting habitat restoration targets in the Delta. Although it is premature to set priorities for the targets and programmatic actions in the Delta, the Commission suggested the following approaches:*

- *Restore and/or enhance lands currently in public or non-profit ownership (or currently in the acquisition process) and designated for restoration, including Twitchell Island,* *Sherman Island, and Prospect Island. Approximately 35,000 acres fall into this category.*

- *Acquire and/or enhance currently flooded lands to create and/or enhance emergent habitat, including Frank's Tract, Big Break, Mildred Island, Little Mandeville Island, etc. Approximately 7,000 acres fall into this category.*

- *Develop and implement management plans for upland areas already in public or non-profit ownership, including Calhoun Cut Ecological Preserve (approximately 1,000 acres), Rhode Island, etc.*

- *Develop and implement individual management plans for private agricultural properties and develop (or provide) funds to offset costs of voluntary implementation of such plans (plans could include flooding programs, enhanced levees and pumps to enhance flooding and drainage, recommend crop rotation cycles, size and location of permanent brood ponds, etc.).*

- *Develop and implement individual management plans for privately owned lands managed for wildlife habitat, such as duck clubs and upland hunting clubs, and develop (or provide) funds to offset costs of voluntary implementation of such plans.*

- *Control of stressors should be revised to avoid duplication with existing regulatory programs, such as existing dredging "windows," and the programs that are developed should respect the needs of existing land uses, such as water-oriented recreation. Where funds are needed to carry out specific programs, those funds should be made available to private land owners to implement CALFED programs.*

*The Delta Protection Commission also suggested the approach for restoring a riparian corridor along the Delta portion of the Sacramento River should consider the ecological benefits of enlarging and enhancing a riparian corridor west of the Deep Water Ship Channel, within the Yolo Bypass. Such a waterway could connect to the main stem of the Sacramento River at either or both the Sutter Weir or the Sacramento Weir. There is an existing channel named the Tod Drain, which lies west of the Ship Channel. The Toe Drain is largely unvegetated by lies within the Yolo Bypass, where the lands are already subject to a flood easement purchased by the federal government to provide additional flood protection the city of Sacramento and the Delta area. While the Sacramento River can maintain flood flows of about 150,000 cfs, the Yolo Bypass can handle about three times as much flood flow (450,000 cfs). Locating an enhanced riparian corridor within the Yolo Bypass would also address the stranding of juvenile and adult fish when flood flows recede. Creating an enlarged channel would improve flood water conveyance capacity in the Yolo Bypass, which would then allow the introduction and maintenance of riparian vegetation into the flood bypass without reducing overall flow capacity during flood events.*

*The Delta Protection Commission also suggested that the South Fork of the Mokelumne River be considered for water conveyance and flood control, by dividing the flow of the Mokelumne River between its north and south forks. Both forks could be examined for additional habitat restoration opportunities as channel capacities are increased by dredging or construction of any necessary levee setbacks. There are significant flow constrictions in the upper reach of the South Fork Mokelumne, which if reduced, could provide important opportunities for flood control and habitat restoration. The Commission suggested that the Mokelumne River corridor must be multipurpose and provide water conveyance through the Delta, flood control for Sacramento and San Joaquin counties, and provide for a riparian corridor for aquatic and terrestrial species.*

**Table 4. Summary of ERPP Habitat Restoration Targets and Programmatic Actions for the Sacramento-San Joaquin Delta Ecological Management Zone.**

| Habitat Type | North Delta Acreage | East Delta Acreage | South Delta Acreage | Central and West Delta Acreage | Total Acreage |
|---|---|---|---|---|---|
| Tidal Perennial Aquatic | 1,500 | 1,000 | 2,000 | 2,500 | 7,000 |
| Shoal | 0 | 0 | 0 | 500 | 500* |
| Nontidal Perennial Aquatic (deep open water) | 0 | 200 | 200 | 100 | 500 |
| Nontidal Perennial Aquatic (shallow open water) | 1,000 | 300 | 300 | 500 | 2,100 |
| Delta Sloughs (short-term) | 10 miles | 10 miles | 25 miles | 20 miles | 65 miles* |
| Delta Sloughs (long-term) | Additional 20 miles | Additional 20 miles | Additional 25 miles | Additional 30 miles | Additional 95 miles* |
| Midchannel Islands | 50 to 200 | 50 to 200 | 50 to 200 | 50 to 200 | 200 to 800* |
| Fresh Emergent Wetland (tidal) | TBD [to be determined] | TBD | TBD | TBD | 30,000 to 45,000 |
| Fresh Emergent Wetland (nontidal) | 3,000 | 3,000 | 4,000 | 10,000 | 20,000 |
| Seasonal Wetland | Improve: 1,000<br>Restore: 4,000 | 1,000<br>6,000 | 500<br>12,000 | 1,500<br>8,000 | 4,000<br>30,000 |
| Riparian and Riverine Aquatic | 10-15 miles plus 500 acres | 8-15 miles | 25-25 miles | | 43-55 miles plus 500 acres |
| Inland Dune Scrub | 0 | 0 | 0 | 50 to 100 | 50 to 100* |
| Perennial Grassland | 1,000 | 1,000 | 1,000 to 2,000 | 1,000 to 2,000 | 4,000 to 6,000 |
| Wildlife Friendly Agricultural Land | TBD | TBD | TBD | TBD | 40,000 to 75,000* |
| Total acres of all habitats to be restored include large acreages that will have minimal impacts on existing land uses such as wildlife friendly agricultural practices, shoal habitat, and inland dune scrub. The largest acreages are for shallow water habitats such as fresh emergent wetlands (tidal and nontidal) and tidal perennial aquatic habitats. Those three total 57,000-72,000 acres. | | | | | 138,350 to 191,000 |
| Total Delta Slough /Riparian and Riverine Aquatic Habitats includes miles of habitat to be improved and an expansion of Stone Lakes and Cosumnes River Preserve by 500 acres. | | | | | 143-220 miles plus 500 acres |

* Denotes acreages that have minimal impact to existing agricultural land uses and practices.

*The Commission also provided information regarding wildlife friendly farming practices. In 1993-94, a Crop Shift Demonstration Project was conducted on Rindge Tract. The California Department of Fish and Game recommended specific measures to mitigate impacts to wildlife from the demonstration project. Most of the mitigation measures were implemented as part of the demonstration project, and project monitoring provided positive results. Based on this demonstration project, a wildlife friendly agricultural practices program should consider the following:*

- *Extend availability of post-harvest flooded grain fields to more fully cover period of usage by migratory birds.*
- *Enhance food value of post-harvest flooded grain fields by intentionally leaving more grain in the fields either by modifying harvest practices or intentionally not harvesting portions of the fields to be harvested.*
- *Create fringe areas during important periods to enhance forage opportunities for species such as greater sandhill cranes and Swainson's hawks.*
- *Disperse the program throughout the Delta to discourage over-concentration of species in a single area.*
- *Maintain the existing agricultural economy of the region by using a voluntary program in which participants receive compensation equal to their cost or loss of income.*

*Overall, the Delta Protection Commission has provided suggestions that will facilitate implementation of the long-term program. Although the recommended actions in this plan are still at the "Programmatic Level," near-term implementation plans and projects can incorporate these suggestions in order to develop actions that can be implemented with support of the Commission.*

## REDUCING OR ELIMINATING STRESSORS

### WATER DIVERSIONS

**TARGET 1:** Reduce loss of important fish species at diversions (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Consolidate and screen agricultural diversions in the Delta.

**PROGRAMMATIC ACTION 1B:** Replace or upgrade the screens at the SWP and CVP intakes with positive-barrier, fish bypass screens and state-of-the-art fish holding and transportation systems. *(Note: The ecological benefits of this action could be substantially improved by selection of an alternative that has a provision to relocate the intakes, screening those intakes, and providing for fish bypasses as needed.)*

**PROGRAMMATIC ACTION 1C:** Upgrade screens at Pacific Gas & Electric Company's Contra Costa power plant with fine-mesh, positive barrier, fish bypass screens.

***RATIONALE:*** *Loss of juvenile fish in diversions is detrimental to fish species of special concern (Larkin 1979; Erkkila et al. 1950).*

### LEVEES, BRIDGES, AND BANK PROTECTION

**TARGET 1:** Increase shoreline and floodplain riparian habitat in the Delta by changing the vegetation maintenance practices on both the water and the land side of berms on 25 to 75 miles of the Sacramento, Mokelumne, and San Joaquin rivers, and on 25 to 100 miles of other Delta channels and sloughs confined by levees (◆◆).

**PROGRAMMATIC ACTION 1A:** Enter into agreements with willing levee reclamation districts to change levee and berm vegetation management practices that to establish and mature shoreline riparian vegetation. This will restore and maintain the health of Delta aquatic resources. Reimburse districts for any additional maintenance and inspection costs.

**RATIONALE:** *Restoring, improving, and protecting high-quality riparian woodland and willow scrub habitat will enhance nutrient cycling and the foodweb and provide habitat for terrestrial invertebrates that will sustain resident fish and juvenile anadromous fish. Terrestrial vertebrates that will benefit include the Swainson's hawk, western yellow-billed cuckoo, neotropical migrant songbirds, and the riparian brush rabbit. This action will also increase suitable habitat for wildlife such as the western pond turtle and wood duck (Bjornn et al. 1991; Shields et al. 1993; Jensen et al. 1987; Fris and DeHaven 1993; Mahoney and Erman 1984; and Knight and Bottorff 1983). Large-scale riparian restoration projects are needed to restore the variety of species and the sustainability and resilience of these habitats to support the ecological functions needed for aquatic resource restoration in the Bay-Delta. This is consistent with the recommended strategy for restoration of rivers and aquatic ecosystems on a large scale (National Research Council 1992; Noss and Harris 1986; Hutto et al. 1987; Scott et al. 1987; Noss et al. 1994).*

## DREDGING AND SEDIMENT DISPOSAL

**TARGET 1:** Limit dredging in channel zones that are not essential for flood conveyance or maintenance of industrial shipping pathways, and avoid dredging in shallow water areas (depths of less than 3 meters at mean high water) except where it is needed to restore flood conveyance capacity (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Use alternate sources (rather than Delta in-channel sources) of levee maintenance material, such as:

- excavation of abandoned nonessential levees,
- excavation material from the restoration of secondary tidal channels,
- dry-side island interior borrow pits,
- upland borrow sites,
- Cache Creek settling basin and Yolo Bypass sediment deposits, and
- deep water dredging sites in the San Francisco Bay.

**PROGRAMMATIC ACTION 1C:** Restrict or minimize effects of dredging near existing Midchannel tule islands and shoals that are vulnerable to erosion and exhibit clear signs of area reduction from channel and bar incision (cutting).

**TARGET 2:** Avoid dredging during spawning and rearing periods for delta smelt and during rearing periods for winter-run chinook salmon (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Follow DFG guidelines for dredging in the estuary.

**PROGRAMMATIC ACTION 2D:** Provide stockpiles of levee maintenance materials in three or more selected land-side areas to avoid the need to obtain material from Delta channels during restricted periods.

**RATIONALE:** *Soils for levee maintenance should not be taken from adjacent Delta waters because such dredging alters the physical and chemical characteristics of the aquatic habitat and disrupts aquatic organisms. Restoring, improving, and protecting high-quality shallow habitat will provide forage for rearing juvenile fish. These areas typically produce high levels of primary and secondary food species and support nutrient cycling that can sustain quality forage. These areas also provide high-quality forage for waterfowl that use submerge vegetation growing in the shoals and diving ducks such as canvasback and scaup that eat clams in these areas (Fris and DeHaven 1993; Britain et al. 1993; Stuber 1984). Losses or impacts to this habitat should be avoided to restore the health of the estuary*

*(Schlosser 1991; Sweetnam and Stevens 1993; Herbold 1994).*

*Impacts that could disrupt foraging and breeding activities of special-status estuarine fish should be avoided (Sweetnam and Stevens 1993; Moyle et al. 1992, Herbold 1994).*

## INVASIVE AQUATIC PLANTS

**TARGET 1:** Manage existing and restored dead-end and open-ended sloughs and channels within the Sacramento-San Joaquin Delta Ecological Management Zone so that the total surface area of these sloughs and channels covered by invasive non-native aquatic plants is reduced (◆).

**PROGRAMMATIC ACTION 1A:** Conduct large-scale, annual weed eradication programs throughout existing and restored dead-end and open-ended sloughs and channels within each of the Delta's Ecological Management Units. The goal is that less than 1% of the surface area of these sloughs and channels is to be covered by invasive non-native aquatic plants within 10 years.

**PROGRAMMATIC ACTION 1B:** Evaluate the feasibility of developing a program to commercially harvest and convert water hyacinth to methane (natural gas) and organic fertilizer.

**TARGET 2:** Reduce the potential for introducing non-native aquatic plant and animal species at border crossings (◆◆◆).

**PROGRAMMATIC ACTION 2A**: Provide funding to the California Department of Food and Agriculture to expand the current State border inspection process to include a comprehensive program of exclusion, detection, and management of invasive aquatic species such as purple loosestrife, and hydrilla.

***RATIONALE:*** *Invasive aquatic plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those from competition for nutrients, light, and space. The prescribed action is primarily to enhance foodweb functions and improve habitat for resident, estuarine, and anadromous fish and neotropical migratory birds, in part, by reducing the areas inhabited by invasive non-native plants and by large-scale restoration of optimal nesting habitat (Dudley and D'Antonio 1994; Anderson 1990; Zedler 1992; Bay-Delta Oversight Council 1994).*

## INVASIVE RIPARIAN AND SALT MARSH PLANTS

**TARGET 1:** Reduce surface area covered by non-native plants to less than 1% (◆).

**PROGRAMMATIC ACTION 1A:** Control non-native riparian plants.

**TARGET 2:** Reduce the area of invasive non-native woody species, such as Giant Reed (i.e., Arundo or false bamboo) and eucalyptus, that compete with native riparian vegetation, by reducing the area of non-natives by 50% throughout the Delta and by eradicating invasive woody plants from restoration areas (◆◆).

**PROGRAMMATIC ACTION 2A:** Implement a program throughout the Delta to remove and suppress the spread of invasive non-native plants that compete with native riparian vegetation by reducing the aerial extent of species such as False Bamboo, eucalyptus, and non-native cordgrass (Spartina spp.) by 50%.

**PROGRAMMATIC ACTION 2B:** Implement a program throughout the Delta that, before restoration actions, eliminates invasive woody plants that could interfere with the restoration of native riparian vegetation.

***RATIONALE:*** *Invasive non-native plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those of competition for nutrients, light, and space. The prescribed actions are primarily to improve habitat for many* *fish and wildlife species and to support foodweb functions by establishing extensive riparian habitat throughout the Delta (Dudley and D'Antonio 1994; Madrone and Assoc. 1980; Bay-Delta Oversight Council 1994; Cross and Fleming 1989; Zedler 1992). There have been extensive Spartina eradication efforts in Willapa Bay, Washington, that could provide guidance in designing and implementing a similar control program in the western Delta and north San Francisco Bay. In most cases, the removal of invasive plants will require the replanting of native vegetation to maintain adequate levels of herbaceous cover, canopy closure, habitat structure, and to limit exotic recolonization.*

## INVASIVE AQUATIC ORGANISMS

**TARGET 1:** Reduce or eliminate the influx of non-native aquatic species in ship ballast water (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Fund additional inspection staff to enforce existing regulations.

**PROGRAMMATIC ACTION 1B:** Help fund research on ballast water treatment techniques that could eliminate non-native species before ballast water is released.

**TARGET 2:** Reduce the potential for introducing non-native aquatic organisms at border crossings (◆◆◆).

**PROGRAMMATIC ACTION 2A:** Provide funding to the California Department of Food and Agriculture to expand the current State border inspection process to include a comprehensive program of exclusion, detection, and management of invasive aquatic species such as the zebra mussel.

***RATIONALE:*** *Every reasonable effort should be made to reduce the introduction of non-native organisms in the ballast water of ships that enter the Delta. Such organisms have greatly altered the zooplankton of the Delta over the past several decades. Further alteration could reduce the capacity of the Delta to support native fishes.*

*Every reasonable effort should be made to reduce the introduction of non-native organisms at overland entrances to California. Inspections at borders have already found Zebra mussels that if allowed to enter Bay-Delta waters could have devastating economic and ecological effects.*

## PREDATION AND COMPETITION

**TARGET 1:** Reduce loss of juvenile fish in Clifton Court Forebay to predation by 75% to 90% (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to reevaluate the need to remove predatory fish from Clifton Court Forebay.

**PROGRAMMATIC ACTION 1B:** Evaluate alternative methods to remove predator fish from Clifton Court Forebay with emphasis on predator removal near the fish facility.

**PROGRAMMATIC ACTION 1C:** Evaluate alternate operational strategies to reduce entrainment of juvenile fish into Clifton Court Forebay.

**TARGET 2**: Reduce in-channel predation loss of juvenile fish near structures such as bridge pilings and diversions (◆).

**PROGRAMMATIC ACTION 1A**: Develop a cooperative program to reevaluate opportunities to modify in-channel structures to eliminate predator habitat.

***RATIONALE:*** *Diversions and other structures may provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern (Erkkila et al. 1950).*

*Predation of juvenile fish in Clifton Court Forebay is a symptom of larger problems. These* *are probably insufficient rearing habitat in the Central Delta, high channel velocities, and insufficient flows in the San Joaquin River. Short-term efforts in Clifton Court Forebay should include, at a minimum, a predator removal or control program near the fish facility and louver system. Additional focused research is needed on longer-term efforts to reduce predation and to improve the understanding of predator population growth. The longer-term solution to predation at this site lies in re-creating rearing and migration habitats throughout the Delta. Some of the water conveyance alternatives in the Delta could decrease the rates of predation by enlarging the forebay and closing the radial gates for longer periods.*

## CONTAMINANTS

**TARGET 1:** Reduce loading, concentrations, and bioaccumulation of contaminants of concern to ecosystem health in the water, sediments, and tissues of fish and wildlife in the Sacramento-San Joaquin Delta Ecological Management Zone by 25 to 50% as measured against current average levels (◆◆).

**PROGRAMMATIC ACTION 1A:** Reduce the input of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife in the Delta by changing land management practices and chemical uses on 50,000 acres of urban and agricultural lands that drain untreated into Delta channels and sloughs. Actions will focus on modifying agricultural practices and urban land uses on a large scale. To reduce the concentration of pesticide residues, the amount applied will be reduced and the amount of pesticide load reaching the Delta's aquatic habitats will be further reduced by taking advantage of biological and chemical processes within wetland systems to help break down harmful pesticide residues.

**PROGRAMMATIC ACTION 1B:** Reduce levels of hydrocarbons and other contaminants entering the Delta foodweb from high releases into the estuary at oil refineries.

***RATIONALE:*** *Reducing the concentrations and loads of contaminants including hydrocarbons, heavy metals, and other pollutants in the water and sediments of the Sacramento-San Joaquin Delta Ecological Management Zone will help ensure reduction of sublethal and chronic impacts of contaminants, whose impacts on population levels are hard to document. (Bay Delta Oversight Council 1994; Hall 1991; U.S. Fish and Wildlife Service 1996; San Francisco Estuary Project 1992b; Sparks 1992; Diamond et al. 1993; Rost et al. 1989).*

*Improved inchannel flows within the Delta from seasonal reductions in water use and improved flows attributed to enhanced supplies of environmental water will also contribute to reducing concentrations (Charbunneau and Resh 1992; U.S. Environmental Protection Agency 1993). Human health warnings associated with consuming fish and wildlife have been issued because of high levels of substances such as mercury and selenium. Large-scale restoration of aquatic and wetland habitats may contribute to reducing levels of hydrocarbons, heavy metals, and other pollutants. However, addressing point sources of concern such as the oil refineries on Suisun and San Francisco Bays and elevated releases of selenium as a result of refining oil from sources high in selenium can also help reduce these contaminants (Charbunneau and Resh 1992).*

## HARVEST OF FISH AND WILDLIFE

**TARGET 1:** Reduce illegal harvest of anadromous fish and wildlife in the Delta by increasing enforcement (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Provide additional funding to the DFG for additional enforcement.

**PROGRAMMATIC ACTION 1B:** Provide additional funding to local county sheriff's departments and local park agencies for additional enforcement.

**PROGRAMMATIC ACTION 1C:** Provide rewards for the arrest and conviction of poachers.

***RATIONALE:*** *Actions to reduce illegal harvest of fish and wildlife are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late fall-run chinook salmon; green sturgeon; splittail; and steelhead. They will also contribute to the recovery of species such as Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake (U.S. Fish and Wildlife Service 1996; San Francisco Estuary Project 1992b; Bay-Delta Oversight Council 1993; California Department of Fish and Game 1991).*

## STRANDING

**TARGET 1:** Reduce or eliminate the stranding of juvenile chinook salmon on floodplains, shallow ponds, and levee borrow areas.

**PROGRAMMATIC ACTION 1A:** Conduct surveys of stranding in the Yolo Bypass under a range of flow conditions and develop recommendations to resolve the problem.

***RATIONALE:*** *Under many flow conditions, stranding is likely in the Yolo Bypass and is a minimal problem. However, under conditions in which the Sacramento River reach high flows and flow is diverted into the flood bypasses, and then flow quickly recede, stranding is likely a serious problem. Timing also plays a important role in determining the severity of the problem. The California Department of Water Resources has been investigating stranding of juvenile fish in the Yolo Bypass and identified areas where remedial actions are probably appropriate to reduce the loss of juvenile fish. Further analysis is needed of the potential magnitude of the problem and additional options to reduce the potential severity of the problem need to be identified.*

## DISTURBANCE

**TARGET 1:** Reduce boat traffic and boat speeds in areas where levees or channel islands and their associated shallow-water and riparian habitat may be damaged by wakes. This will protect important Delta habitats such as berm islands from erosion caused by boat wake (◆◆).

**PROGRAMMATIC ACTION 1A:** In the Central and West Delta Ecological Management Unit, establish and enforce no wake zones of 1 to 3 miles in Disappointment Slough, of 1 to 2 miles in White Slough, and of 3 to 4 miles in Middle and Old rivers in areas with remnant berms and midchannel islands.

**PROGRAMMATIC ACTION 1B:** In the East Delta Ecological Management Unit, establish and enforce no wake zones of 1 to 3 miles of the Mokelumne River, of 2 to 4 miles in Snodgrass Slough, and of 3 to 4 miles in Beaver, Hog, and Sycamore Sloughs in areas with remnant berms and midchannel islands.

**TARGET 2:** Reduce boat wakes near designated important California black rail nesting areas in the Delta from March to June to levels necessary to prevent destruction of nests. This will help in recovery of this listed species (◆◆).

**PROGRAMMATIC ACTION 2A:** Establish and enforce no wake zones within 50 yards of important California black rail nesting areas in the Delta from March to June.

**PROGRAMMATIC ACTION 2B:** Establish and enforce no motorized boating zones in 5 to 25 miles of existing dead-end channels in the Delta from March to June.

**PROGRAMMATIC ACTION 2C:** Establish and enforce no motorized boating zones in the small tidal channels created in restored tidal freshwater marshes and Delta floodplains of levee setbacks.

**TARGET 3:** Reduce boat wakes near important shallow water spawning areas in the Delta from March to June to levels necessary to protect successful spawning behavior and success. This will help in recovery of listed species (◆).

**PROGRAMMATIC ACTION 2A:** Identify important shallow water spawning areas and establish and enforce no wake zones within 50 yards of these important Delta habitats from March to June.

***RATIONALE:*** *Protecting the highest quality and largest berm island complexes will advance the ERPP's strategy of protecting and restoring large areas of habitat rather than small fragmented areas (National Research Council 1992; Resource Agency 1976; San Francisco Estuary Project 1992a; San Joaquin County 1979; U.S. Fish and Wildlife Service 1992).*

*Actions taken to restore ecological processes and functions, increase and improve habitats, and reduce stressors in this Ecological Management Zone are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. They will also contribute to the recovery of species such as the black rail. (Madrone 1980; Schlosser 1991; San Francisco Estuary Project 1992a; U.S. Fish and Wildlife Service 1978; Schlorff 1991).*

*Additional research is needed to identify important shallow water spawning areas and the potential adverse effects of boat traffic on the spawning success of native Delta fishes.*

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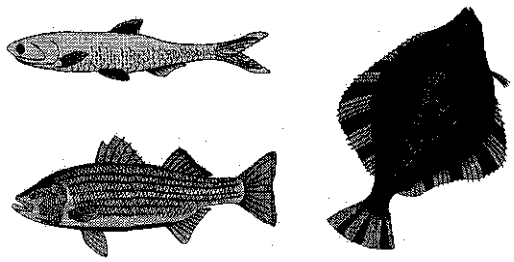
# ◆ Suisun Marsh/North San Francisco Bay Ecological Management Zone



## Introduction

Suisun Marsh and North San Francisco Bay are the portions of San Francisco Bay downstream of the Delta and upstream of Central San Francisco Bay. These areas include San Pablo and Suisun Bays, the adjacent Suisun Marsh, and the Contra Costa shoreline. North Bay was once bordered on the north by extensive marshes. Baylands alteration has now reduced the marshes to northern San Pablo Bay and Suisun Bay, including Petaluma, Napa, and Suisun marshes. Healthy marshes provide many ecological benefits including very high productivity, flood moderation and shoreline protection. Many of the tidal emergent marshes have been reclaimed for agriculture, salt production, duck clubs, and managed freshwater marshes. These lands are protected from flooding by hundreds of miles of levees. Remnants of the tidal salt marshes remain along the margins of San Pablo and Suisun Bay. The largest intact undiked wetlands remaining in Suisun Marsh are associated with Cutoff Slough and Hill Slough in north central Suisun Marsh.

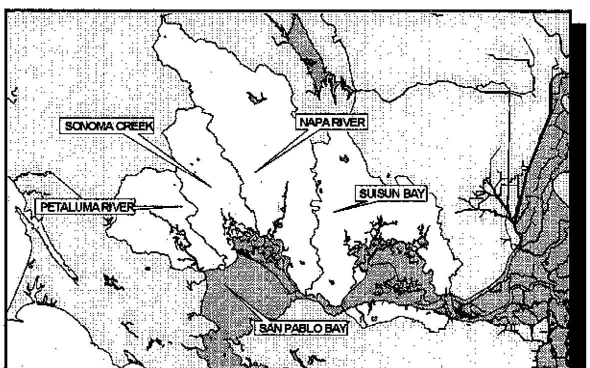
Suisun Marsh and North San Francisco Bay support many species of native and non-native fish, waterfowl, shorebirds, and other wildlife. This ecological management zone also supports many native plant communities including several significant rare and endangered plants which are dependent of wetland processes. All Central Valley anadromous fish migrate through the North Bay and depend on the North Bay and marshes for some critical part of their life cycle. Many Pacific Flyway waterfowl and shorebirds pass through or winter in the North Bay and marshes. The North Bay and adjacent marshes are important nursery grounds for many marine, estuarine and anadromous fish species. Four runs of chinook salmon, steelhead, green sturgeon, white sturgeon, striped bass, lamprey, and American shad migrate through the Delta on their journey between the Pacific Ocean and Central Valley spawning rivers. Young salmon may spend important weeks and months feeding in the North Bay and marshes before migrating to the ocean. Many sturgeon and striped bass spend much of their lives in the North Bay. Many marine (ocean) species depend on the North Bay as nursery area for young, including Pacific herring, northern anchovy, and Dungeness crab. Native resident fish, including longfin smelt, delta smelt, and splittail, spend much of their lives within the North Bay and marshes. Considerable areas of waterfowl and wildlife habitat occur on and along the margins of the North Bay and in the marshes.

Ecological factors having the greatest influence on North Bay and marsh fish and wildlife include freshwater inflow from rivers, wetlands, riparian vegetation, and aquatic habitat diversity. Stressors include water diversions, poor water quality, legal and illegal harvest, wave and wake erosion, and introduced non-native plant and animal species. Stressors to Suisun and North Bay saline emergent plant communities supporting sensitive plant and wildlife resources include freshwater discharges which are outside of the natural variability of seasonal runoff. For example, fresh wastewater treatment outfalls sustained outside of the normal runoff season have been proven detrimental to saline emergent wetlands. Stressors may also include water management activities which result in increased depth and duration of flooding in high marsh zone beyond the range of natural variability and seasonality.

## DESCRIPTION OF THE MANAGEMENT ZONE

The Suisun Marsh/North San Francisco Bay Ecological Management Zone is the westernmost zone of the Ecosystem Restoration Program Plan (ERPP). Its eastern boundary is the Collinsville area, and to the west it is bounded by the western end of San Pablo Bay. The northern boundary follows the ridge tops of the Coast Ranges and includes the Petaluma River, Sonoma Creek, the Napa River, and San Pablo Bay. This Ecological Management Zone is composed of five Ecological Management Units:

- Suisun Bay and Marsh,
- Napa River,
- Sonoma Creek,
- Petaluma River, and
- San Pablo Bay.



Map of the Suisun Marsh/North San Francisco Bay Ecological Management Zone and Units.

The general structure of San Francisco Bay is that of a series of embayments, each containing a central expanse of open water overlying subtidal sediments, and ringed by intertidal wetlands, mudflats, and /or rocky shores. These different kinds of areas constitute the major distinctive habitat-types of the ecosystem. Hydrologically, the Bay may be divided into two broad subdivisions with differing ecological characteristics: a *southern reach* consisting of South Bay, and a *northern reach* composed of Central, San Pablo, and Suisun Bays. The southern reach receives little freshwater discharge, leading to high salinity and poor circulation. It also has more extreme tides. The northern reach (which this vision addresses) directly receives Delta outflow, is characterized by less extreme tides and a pronounced horizontal salinity gradient, ranging from near full marine conditions in Central Bay to near fresh water conditions in Suisun Bay. Central and Suisun Bays contain sizeable islands, features not present in San Pablo and South Bays.

Historically (ca 1800), San Francisco Bay included more than 242,000 acres of tidally influenced bayland habitats and about 90,000 acres of adjacent habitats (Goals Project 1999). Tidal marsh (190,000 acres) and tidal flats (50,000 acres) accounted for 98% of the bayland habitats. Today, only 70,000 acres remain. In the Suisun Bay and marsh, tidal marsh and tidal flat habitats have declined from 68,000 acres to about 15,000 acres. Similar declines have occurred in the North Bay region with tidal marsh and tidal flats declining from about 68,000 acres to about 25,000 acres (Goals Project 1999).

Today, the important habitat types in the Suisun Marsh/North San Francisco Bay Ecological Management Zone are tidal perennial aquatic habitat, tidal saline emergent wetland, seasonal wetland, perennial grassland, agricultural land, and riparian habitat. The separation of wetlands from tidal flows and the reclamation of emergent wetlands have altered ecological processes and functions in Suisun Marsh and the North Bay. Removing tidal action from the marsh and baylands soils has resulted in oxidation of the soil and, subsequently, subsidence (settling) of interior islands and adverse changes in wetland soils chemistry. Losing these processes and functions has reduced available habitat for native species of fish, plants, and wildlife; reduced water quality;

and decreased the area available for dispersing flood waters and depositing suspended silt.

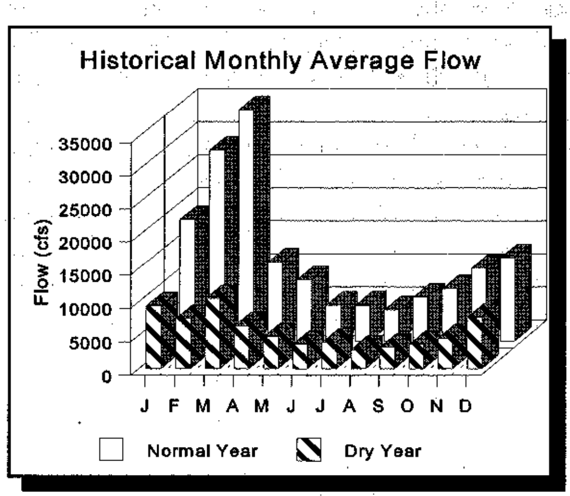
Species that have been affected include the salt marsh harvest mouse, California clapper rail, California black rail, waterfowl, shorebirds, Suisun shrew, and many other wildlife species. Many special-status plant species, including the soft-haired bird's beak, Suisun thistle, and Suisun aster, have also been adversely affected. Many species of native marine, estuarine, freshwater, and anadromous fish also depend on this habitat type for important parts of their life cycles. Fish species that continue to depend on tidal marshes and adjoining sloughs, mudflats and embayments include delta smelt, longfin smelt, chinook salmon, green sturgeon, white sturgeon, Pacific herring, starry flounder, splittail, and striped bass.

Submerged aquatic vegetation (SAV), especially seagrass, communities and habitats provide valuable habitat for fish and invertebrates in the San Pablo Bay and north San Francisco Bay and is an important foraging habitat for waterfowl. San Pablo Bay contains the greatest acreages of seagrass of any water body in the Bay-Delta system. The relative present-day rarity of seagrass beds suggests it could be considered a habitat of special concern in the system.

Ecological processes essential to a healthy Suisun Marsh and San Francisco Bay include freshwater inflow, flood and floodplain processes, and aquatic foodweb processes. The disruption of ecological processes in this zone, such as separating wetlands from tidal flows, has prevented the marshes from the accretion of bottom sediments necessary to keep up with sea level rise, reduced nutrient input to the zone, and reduced the output of other organics and fixed nutrients. Ecological processes essential to a healthy Suisun Marsh and San Francisco Bay include both freshwater inflow within natural (unimpaired) variability and also tidal inflow to deliver important ocean salts and maintain this brackish-saline system. In addition, rare events such as extreme pulse flow hydrographs associated with high outflow years and rare events such as extreme winter drought conditions which this system experienced historically may be equally important in maintaining the biological diversity of this mixed salinity zone.

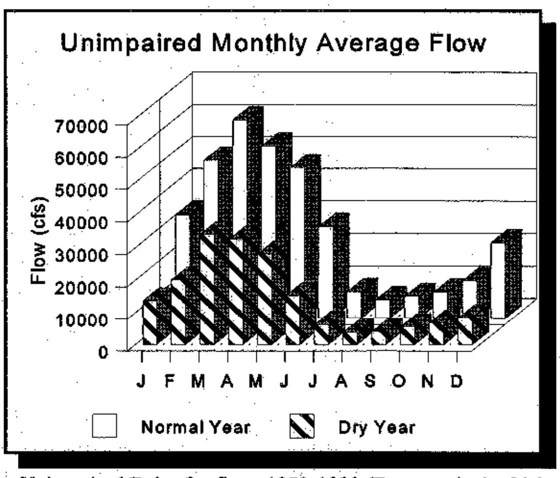
Hydrology is the physical process with the greatest influence on aquatic and wetland habitats, the many species of plants and animals that use the Bay, and the concentrations of pollutants in the marshes and North Bay. In areas downstream of the X2 isohaline (low salinity zone) which are well-mixed, ocean tides clearly dominate over and above freshwater inflow. The historical dominance of halophytic vegetation in Suisun Marsh also suggests that tidal hydrology may be more important to Suisun than freshwater inflows. The historical tidal prism prior to diking of the Suisun and North Bay marshes was also higher than present condition.

Freshwater inflow to the North Bay varies greatly from year to year. In 70 years of historical record, Bay inflow has ranged from a high of 50 million acre-feet (af) to a low of 8 million af, with an average of approximately 24 million af. During this period, freshwater inflow to the Bay has changed markedly because of upstream water storage in reservoirs and water-supply diversions developed in 1940s, 1950s, and 1960s. Spring freshwater inflows, which once averaged 20,000




Historical Delta Outflow, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

to 40,000 cubic feet per second (cfs) in dry years and 40,000 to 60,000 cfs in normal years, now average only 6,000 to 10,000 cfs in dry years and 15,000 to 30,000 cfs in normal years. In the driest years, spring freshwater inflows from the Delta were formerly 8,000 to 14,000 cfs; presently these flows average only 2,500 to 3,000 cfs. In dry and normal years, summer flows have remained in the range of 4,000 to 8,000 cfs, because channels carry irrigation water and Delta outflow needed to meet water quality criteria in the Delta. Winter freshwater inflows from the Delta in dry and normal years have been reduced from former levels of 15,000 to 60,000 cfs to current levels of 7,000 to 35,000 cfs because much of the runoff from winter rains and snowmelt is now stored in foothill reservoirs. Flows in highest rainfall years are relatively unchanged, although short-term peaks are reduced by flood-control storage in large foothill reservoirs.




Unimpaired Delta Outflow, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Freshwater inflows from the local watershed in the Vaca Mountains and Coast Range have also been modified from historic conditions. This influence, however, needs further review to clarify potential adverse downstream impacts.

Natural flood and floodplain processes are the periodic inundation of the floodplain during tidal cycles and peak flow events that would typically occur in late winter and spring during all but the driest years. Land reclamation and levee construction have eliminated much of the natural North Bay floodplain. This floodplain reduction forces water to rapidly exit the marshes and bays through confined channels and sloughs. While flows in most high rainfall years may be relatively unchanged, very large floods can devastate shoreline areas of the North Bay due to loss of floodplain and flood basin storage and other dampening effects of floods.

Aquatic foodweb productivity in the North Bay has declined over the past several decades due to several factors, including loss of tidal exchange, changes in freshwater inflow, Delta conditions, water diversions, water quality, and the introduction of exotic species. Foodweb productivity, beginning at the primary production level (i.e., plant cell production), is essential to maintaining important fish population. Primary productivity in the North Bay and adjacent marshes depends on spring freshwater flow events to bring in essential nutrients and recycle nutrients in the marshes. Primary productivity has been limited by heavy infestations of Asian clams that efficiently filter algae from the water column thus reducing the standing crop of phytoplankton.

With the reclamation of tidal marshes in the North Bay, there was an accompanying loss of shallow-water aquatic habitats on which many marine, estuarine resident and anadromous fish and estuarine invertebrates depend. Shallow-water habitats around the North Bay provide spawning and rearing habitat for many native resident Bay-Delta fishes and important rearing and migratory habitat for many Central Valley salmon and steelhead populations. Tidal perennial aquatic habitat benefits native waterfowl, wading and shorebirds, and other wildlife, as well as native plants that depend on such habitat.

Lakes and ponds (nontidal perennial aquatic habitats) found behind levees on reclaimed islands support simple invertebrate communities, riparian habitat, and wintering waterfowl. Such habitat within the North Bay also benefits waterfowl, as well as many plant and wildlife species.

After more than 100 years of land reclamation activities in the North Bay and marshes, many linear miles of natural sloughs have been lost. Sloughs are important spawning and rearing areas for many Bay-Delta fish species, as well as waterfowl and other wildlife. Of the natural sloughs that remain, most have severely degraded natural habitat values from loss of the tidal prism, dredging, levee confinement, riparian vegetation loss, high water flow, and poor water quality (i.e., from municipal, industrial, and agricultural drains).

Tidal marshes (including tidal perennial aquatic habitat, saline emergent wetlands, tidally influenced fresh emergent wetlands, and sloughs), once the most widespread habitat in the Bay-Delta, are now restricted to remnant patches. There have been extensive losses of saline emergent wetland habitat in the North Bay and adjacent marshes. Most of the remaining saline emergent wetlands lack adjacent upland transition habitat and other attributes of fully functioning saline emergent wetlands because of agricultural practices and urban and industrial development. Saline emergent wetlands provide important habitat for many plants, waterfowl, and other wildlife species. In addition, saline emergent wetlands contribute important plant detritus and nutrient recycling to the aquatic foodweb of the Bay-Delta estuary, as well as important habitat to some fish and aquatic invertebrate species.

Seasonal wetlands include vernal pools, wet meadows or pastures, and other seasonally wetted habitats, such as managed duck clubs. Most of this habitat is located on levee-protected lands. Such habitats were once very abundant during the winter rainy season or after seasonal flooding. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from directed overflow of flood waters to bypasses, or from flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many waterfowl, shorebird, and other wildlife species.

Upland habitats are found mainly on the outer edges of the North Bay and adjacent marshes. They consist primarily of grasslands and remnant oak woodland and oak savanna (intermittent woodland and grassland). Perennial grasslands are an important transition habitat for many wildlife species and are buffers to protect wetland and riparian habitats. Much of the grassland habitat associated with wetlands has been lost to agriculture (i.e., pasture, grain, vineyards, and orchards) and development (i.e., home construction, golf courses). Grasslands are important buffers for wetland habitat and provide habitat for many plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees, berms, berm islands, and in the interior of some islands. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitat provide the shaded riverine aquatic habitat that many important fish and wildlife species depend on during some portion of their life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse habitat structure with low species diversity.

Riparian habitat is used by more wildlife than any other habitat type. From about 1850 to the turn of the century, most of the riparian forests in the Bay-Delta were cut down for fuelwood as a result of the Gold Rush, river navigation, and agricultural clearing. Remnant patches are found on levees, channel islands, and along the margins of the North Bay and adjacent marshes. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many fish and wildlife species.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors (soaring birds of prey, such as hawks and eagles). Nonflooded fields and pastures are also habitat for pheasants, quail, and doves. The North Bay and adjacent marshes support a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields, which support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations. The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Bay-Delta.

Water diversions in the North Bay and adjacent marshes divert freshwater inflow and brackish waters. Though diversions vary seasonally, relatively high rates can occur in any month of the year. Most water diverted from the North Bay and marshes is used locally. With many diversions unscreened or poorly screened, great numbers of fish and aquatic invertebrates are lost. In addition to organisms, diversions remove a disproportionately large portion of the nutrients and detrital (organic debris) load that drive the Bay-Delta foodweb. Losses of fish, invertebrates, and nutrients and organic debris limit the potential for the recovery of many fish species and improving Bay-Delta aquatic foodweb productivity. Lack of adequate screening and location of water diversions in sensitive areas contribute to the loss of important fish and aquatic foodweb organisms.

Levee construction and bank protection have led to the loss of wetland and shallow-water habitat throughout the North Bay and adjacent marshes. Habitat on levees and shorelines needs improvement to restore biodiversity and ecological functions needed for Bay-Delta aquatic and wildlife resources. Riparian habitats in this zone are found along the tributary streams in the upper reaches. Riparian habitat is not generally found in areas subject to reclamation by levee construction due to high salinity.

Dredging and disposal of dredge materials have contributed to the loss and degradation of important aquatic habitats such as tidal wetlands, mudflats, and sloughs in the North Bay and adjacent marshes.

Over the past several decades, the accidental introduction of many marine and estuarine organisms from the ballast waters of ships from the Far East has greatly changed the planktonic and benthic invertebrate fauna of the Bay-Delta, with further ramifications higher in the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta.

Toxins continue to enter the North Bay and adjacent marshes in large amounts from municipal, industrial, and agricultural discharges. The toxins have had a demonstrated effect on the health, survival, and reproduction of many important Bay-Delta fish and their foodweb organisms. Toxins in fish tissues are also a health risk to people who eat Bay-Delta fish. Continued reductions of toxins from discharges and releases from the sediment (e.g., disturbed by natural forces and dredging) are essential to the restoration program.

The legal and illegal fish harvest may limit recovery of some populations in the Bay-Delta and its watersheds. Sturgeon harvest in the North Bay and elsewhere may affect recovery of these populations.

Boat traffic in sloughs and channels contributes to the erosion of remaining shallow water, riparian, and wetland habitat. High boat speeds and traffic in channels where remnant or restored habitats are exposed to wave erosion jeopardize remnant habitat and limit the potential success of habitat restoration efforts. For example, an increase in jet ski use in Suisun Marsh following the improvement of local public launch facilities is also causing erosion and noise disturbance problems directly impacting sensitive channel side plant communities and nesting clapper rails in relict tidal marsh habitats.

The delta smelt population of the Bay-Delta estuary is a federally and state-listed threatened species. It depends on the North Bay and adjacent marshes for spawning and rearing habitat. It lives in fresh and brackish bays and sloughs of the Bay-Delta. Its decline is related to poor habitat conditions during drought periods. It benefits from high freshwater inflow, particularly during the late winter and spring of dry years, adequate slough and shallow water habitat, reduced effects of water diversions, and increased the aquatic foodweb productivity.

The longfin smelt populations of the Bay-Delta lives within the brackish water and saltwater of northern San Francisco Bay and migrates upstream into the Delta to spawn. The decline in the longfin smelt population has coincided with a number of changes in the estuary including: low flows in late winter and spring, reduced freshwater flows through the Delta and into Suisun Bay, water diversion (particularly in drier years), and contaminants.

Like delta smelt, splittail is a native resident species of the Bay that depends on the North Bay and adjacent marshes for much of its life cycle for spawning, rearing, and feeding. The splittail is a recently listed federal threatened species. The Bay-Delta population has declined, especially during recent droughts. Splittail depend primarily on shallow water habitats, including shorelines, sloughs, and aquatic habitats associated with wetlands and floodplain lands subject to seasonal inundation (e.g., the adjacent marshes of the North Bay). The splittail population benefits from wetland and slough habitat, a more productive aquatic foodweb, and higher late winter and spring freshwater flows during dry years. Losses to water diversions may also be a limiting factor.

White sturgeon and green sturgeon populations in the Central Valley use the North Bay for migrating, feeding, and as a nursery area for young and juveniles. Populations appear to be stable, but the green sturgeon is a California species of special concern due to low population size. Sturgeon benefit from high late winter and spring freshwater inflow, a productive aquatic foodweb, and bay habitat. Legal and illegal harvest and losses to water diversions may be limiting population abundance.

All four runs of chinook salmon in the Central Valley depend on the North Bay and adjacent marshes during at least a portion of their life cycle. The North Bay and adjacent marshes provide migratory and rearing habitat for salmon in all months. Many chinook salmon populations have declined in recent decades from a combination of ocean, river, and Bay-Delta factors. Freshwater flow reductions through the Bay-Delta and increases in water diversions have led to declines in salmon populations. Improving late winter and spring freshwater flows through the Bay-Delta and reducing losses to diversions are essential needs in salmon recovery.

Chinook salmon also benefit from lower water temperatures in spring and fall, as well as adequate aquatic habitats and high foodweb productivity. Tidal perennial marsh habitat and adjoining sloughs and aquatic habitats in the North Bay and adjacent marshes are important juvenile rearing habitat. Juvenile chinook salmon are lost to water diversions in North Bay and adjacent marshes.

Steelhead were historically present in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units, and are still present in most of these streams. The major factor limiting steelhead populations in these streams is agricultural development including water diversion, barriers due to diversion dams, high water temperatures and other water quality impacts from urban and agricultural runoff.

The striped bass population of San Francisco Bay and the Sacramento and San Joaquin rivers depends on the North Bay and adjacent marshes for much of its life cycle. The North Bay and adjacent marshes provide important feeding and juvenile rearing habitat for striped bass. Reduced freshwater flow and increased water diversions have resulted in a declining striped bass population over the past several decades. Poor Bay-Delta water quality may also be limiting survival of young and adults. Striped bass also benefit from high aquatic foodweb productivity. Loss of tidal perennial aquatic, wetland, and slough habitats may also limit striped bass production. Many striped bass young are lost in water diversions. Artificially rearing young striped bass salvaged at south Delta pumping plant fish facilities or supplementing production with hatchery reared fish may be necessary to sustain the population under present limiting factors.

American shad is an anadromous fish that spawns in the Sacramento River and its major tributaries. They pass through the Bay-Delta on their upstream spawning migration in spring, and in the fall, young fish pass through on their way to the ocean. A small portion of the population rears in North Bay waters. Though the population appears stable and healthy, low productivity in drought periods is a concern. American shad production is higher with higher late winter and spring freshwater flow through the Bay-Delta in dry and normal rainfall years, improved aquatic foodweb production, and lower relative rates of water diversions.

There are many native and non-native fish species resident to the Delta, like delta smelt and splittail, that will benefit from improved aquatic habitats and foodweb production in the Delta. Many native fish species have declined gradually over the past century from habitat loss and non-native fish introductions. More recently native resident (nonmigratory) species have further declined from changes in freshwater flow, water diversions, poor water quality, and further non-native species introductions and habitat degradation. For many of these species, improvements to their native habitats, including sloughs and tidal marshes, are essential in restoring these populations. Native residents will also benefit from more natural freshwater flow patterns, improved water quality, and reduced losses to water diversions.

Marine fishes include many species that are abundant and important ecologically in the Bay and coastal waters. Two ecologically valuable species are the Pacific herring and northern anchovy, whose young are important in the foodweb as prey of salmon, sturgeon, and striped bass, as well as other fish and waterfowl such as cormorants and terns. Pacific herring, Dungeness crab, and Bay shrimp also support commercial fisheries. Starry flounder contribute to the local Bay-Delta sport fishery. The Bay and Delta are essential spawning and nursery areas for many marine fish and invertebrates found in the Bay and coastal waters.

Factors that affect the survival and production of marine fish and invertebrates in the Bay-Delta include Delta outflow, water diversions, foodweb productivity, availability and quality of shallow water and wetland habitats, and water quality. In addition, the aquatic foodweb is linked to the transitional wetland foodweb which extends up into the high marshes and adjacent uplands. These are important ecological links which contribute to the detrital based portion of the aquatic foodweb.

Improvements in production and survival of marine and estuarine fishes in the Bay and Delta will provide ancillary benefits to important estuarine, anadromous, and resident fishes of the Bay-Delta.

Many marine species depend on the North Bay and adjacent marshes for spawning or as nursery areas. Pacific herring spawn in the Bay each winter, and their young are abundant in the North Bay into summer. Young northern anchovy spawned in the ocean enter the North Bay each summer to feed. Starry flounder, shiner perch, and many other marine-estuarine fish also use the Bay for spawning, rearing, and feeding. Dungeness crab use the North Bay as a nursery area. Several shrimp species are abundant in the North Bay.

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

Once possibly abundant, the giant garter snake and western pond turtle are now rare in the Bay-Delta. Improvements in wetland, riparian, and grassland habitats around the Delta margins could greatly benefit these species.

Once abundant in the Bay-Delta, Swainson's hawks are now rare. Improvements in agricultural, grasslands, and riparian habitats will aid in Swainson's hawk recovery.

The California clapper rail is State and federally listed as an endangered species. A long-term decline in tidal emergent wetlands has reduced the population in the Bay-Delta.

A long-term decline in emergent wetlands has reduced the California black rail population in the Delta. Restoring emergent wetlands in the Delta should aid in California black rail recovery.

The Suisun song sparrow lives only in the Suisun Bay marshes. It depends on brackish marsh and riparian habitats. Its population has declined with the loss of brackish marshes.

The salt marsh harvest mouse is a State and federally listed endangered species. It depends on tidal salt marshes and its population has declined with the loss of tidal salt marsh habitat.

Herons, egrets, and other shorebirds and wading birds breed and winter throughout the Central Valley, the North Bay, and adjacent marshes. Their populations depend on aquatic and wetland habitats. Shorebirds and wading birds will benefit from restoring wetland, riparian, aquatic, and agricultural habitats.

Many waterfowl species overwinter in the Bay-Delta and depend on high-quality foraging habitat to replenish their energy reserves. They depend on wetland, riparian, aquatic, and agricultural habitats. Many resident and migratory waterfowl species will benefit from improved aquatic, wetland, riparian, and agricultural habitats.

## List of Species to Benefit from Restoration Actions in the Suisun Marsh/North San Francisco Bay Ecological Management Zone

- delta smelt
- longfin smelt
- splittail
- chinook salmon
- steelhead trout
- striped bass
- green sturgeon
- white sturgeon
- American shad
- native resident fishes
- Pacific herring
- marine fishes and shellfishes
- Bay-Delta foodweb organisms
- grass shrimp
- special status plants
- California freshwater shrimp
- giant garter snake
- western pond turtle
- Swainson's hawk
- California clapper rail
- California black rail
- Suisun song sparrow

- salt marsh harvest mouse
- San Pablo California vole
- Suisun ornate shrew
- shorebirds
- wading birds
- waterfowl
- Delta green ground beetle.

## Descriptions of Ecological Management Units

### Suisun Bay and Marsh Ecological Management Unit

The boundaries of the Suisun Bay and Marsh Ecological Management Unit are Collinsville on the east, the Contra Costa County shoreline to the south, the Richmond-San Rafael Bridge to the west, and the ridge tops of the Coast Ranges to the north. The marshland and bay are in a valley, bordered on the north and south by the Coast Ranges. The predominant habitat types in this zone are tidal perennial aquatic habitat, tidal brackish emergent wetland, seasonal nontidal wetland, and grassland. The marsh is primarily a managed wetland, with levees to control water level and seasonal flooding with fresh water.

Historically, the eastern portion of Suisun Marsh was predominantly tidal fresh and brackish water marsh. The western portion of the marsh was predominately fresh and brackish marshland with more saline marsh existing on the western edge. Within these broad marshes were sloughs, channels, ponds, and small bays. Except for parts of Suisun Bay, the segment had relatively few tidal flats. Large areas of moist grasslands connected the baylands with upland areas (Goals Project 1999).

An extensive network of sloughs conveys tidal flows and some freshwater flow into the marsh. Montezuma Slough, the largest of these, is connected to Suisun Bay at its eastern and western ends. The slough is an important nursery area for many fish, including chinook salmon, striped bass, splittail, and delta smelt. The Suisun Marsh Salinity Control Structure was constructed near the eastern slough entrance and began operation in the fall of 1988 to limit the tidal influx of saltwater from the Bay into Suisun Marsh. The salinity control structure operates from September through May by closing during flood tides and opening during ebb tides to keep salinity in the slough low throughout the managed wetland flooding season.

Efforts in the 1970s resulted in protecting the Suisun Marsh, the largest remaining brackish marsh in California. The marsh is an extremely important resource for migratory waterfowl, associated wildlife (including several threatened and endangered species), and many fish species. The marsh also harbors sensitive plant species and communities including several rare species. The Suisun thistle is a Suisun endemic and is found nowhere else in the world. The Suisun Marsh Protection Plan played a key role in reducing development pressure and other adverse impacts associated with human disturbance, such as accidental fires, careless application of pesticides and herbicides, and urban runoff.

### Napa River Ecological Management Unit

The Napa River Ecological Management Unit is within the Napa River watershed and includes the river, an extensive marsh/slough complex, and the lower river estuary connecting to San Pablo Bay. Historically, this area was nearly all tidal salt marsh and tidal brackish marsh dominated by the flow patterns of the lower Napa River (Goals Project 1999). Currently, most of the baylands have been reclaimed for salt or agricultural production. A network of sloughs fringed by saline emergent marsh is also present. The sloughs have become silted as a result of lost tidal prism. The baylands are surrounded by uplands composed primarily of grasslands which are rapidly being converted to urban and agricultural (vineyard) uses. In the north, natural upper river watershed habitats have been reduced by agricultural and urban development and flood control measures. Vernal pools and other seasonal wetland habitats characteristic of the upper watershed have been almost entirely eliminated in the Napa River Ecological Management Unit.

The Napa River historically consisted of a fairly broad riparian corridor and programs to restore riparian and shaded riverine aquatic habitat will be an important component of the program, particularly in the upper Napa River area to provide habitat for wildlife and aquatic habitat for fish species. The tidal marshes of this area are of limited size and habitat quality due to past reclamation. Remaining tidal marshes are linear with little channel development. The larger sloughs have silted up due to a reduced tidal prism.

## Sonoma Creek Ecological Management Unit

The Sonoma Creek Ecological Management Unit is located southwest of the Napa River Ecological Management Unit. The main habitat types in the area are tidal and seasonal marsh, tidal sloughs, and upland areas, such as vernal pools, grassland, and savanna. Historically, this area was nearly all tidal salt marsh and tidal brackish marsh. Some areas of moist grasslands existed to the north and west along upper Sonoma Creek and in the drainages surrounding Lake Tolay (Goals Project 1999).

The lower portions of the unit are baylands, composed of tidal sloughs with fringing marshes, some diked managed wetlands, diked farm lands, mostly oat and hay, and surrounding uplands characterized by grasslands, vernal pools, and oak woodlands quickly being converted to vineyards. Tidal marshes and channels are reduced as a result of reclamation. Seasonal wetlands develop during the rainy season on reclaimed agricultural lands. Urban development along the upper river is associated with the city of Sonoma. Vineyards are the predominant land use in the upper watershed, particularly on the valley floor. The mountains of the watershed are characterized by oak woodlands, chaparral, and mixed conifer habitats. As in the Napa River Ecological Management Unit, much of the vernal pool, seasonal wetland and oak savanna habitat previously present on the valley floor has been eliminated as a result of agricultural and urban development.

## Petaluma River Ecological Management Unit

The Petaluma River Ecological Management Unit is located west of the Sonoma Creek unit on the northwest margin of San Pablo Bay. The habitat types in this watershed are marsh wetlands and uplands, such as grassland. The lower portion of the watershed is composed of tidal marshes and sloughs, and diked seasonal wetlands and historic bayland which have been reclaimed for agriculture. Historically, tidal marsh was the dominant habitat type in this ecological management unit. Salt marsh existed near the mouth of the Petaluma River, and small tidal flats existed at the river mouth (Goals Project 1999).

The diked agricultural lands intermittently pond water during the rainy season which provided habitat for shorebirds and waterfowl. The surrounding uplands are characterized by open grasslands and oak savannas. This unit contains the largest extant natural tidal marsh on the west coast. The upper watershed is rapidly developing with Petaluma, the largest city. Agricultural uses include grazing, oat hay production, and vineyards.

## San Pablo Bay Ecological Management Unit

The San Pablo Bay Ecological Management Unit includes San Pablo Bay and the adjacent mudflat and marsh baylands, both diked and non-diked. Habitat varies from deep bay marine habitat to edge mudflats and marsh/slough complexes. Bay habitat varies from nearly fresh water at its eastern end, during periods of high freshwater outflow, to nearly seawater salinity levels (32 parts per thousand) during the periods of lowest outflow at the western end of San Pablo Bay. Salinity in the bay is stratified (layered) during high outflow conditions, but is not stratified in dry periods/years. The mixing zone is upstream is San Pablo Bay in dry years.

Historically, this unit supported large tidal marshes that were bordered by extensive mudflats (Goals Project 1999). Although it is generally less productive than the less saline Suisun Bay to the east, San Pablo Bay is a productive estuary that has important spawning and rearing habitat for many marine, estuarine, and anadromous fish and marine-estuarine invertebrates (e.g., shrimp, crabs, and clams).

## VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone includes the concept of "whole marsh management." This vision embodies key parameters needed to successfully restore ecological processes, habitats, and to restore, maintain, or recover a wide diversity of fish, wildlife, and plant species.

The Goals Project (1999) proposed a series of key considerations in restoration of the Suisun Marsh/North San Francisco Bay Ecological Management Zone. The considerations include:

- large, connected patches of tidal marsh habitat centered on existing populations of species concern (e.g., salt marsh harvest mouse, California clapper rail),
- placement of tidal marshes along the edge of the Bay an at the mouths of tributary streams to maximize benefits for aquatic organisms,
- incorporating natural features such as large tidal channels, marsh ponds, transitional pannes, and beaches to optimize habitats for many species of fishes, shorebirds, and waterfowl,
- utilize managed saline and seasonal ponds near mudflats to provide high-tide habitat for shorebirds,
- provide natural habitat transitions between bayland habitats and adjacent upland habitats to provide habitat required by many special status plant species,
- provide continuous corridors of riparian habitat along streams tributary to the Bay, and
- maintain upland buffers to protect all existing and restored wetland habitats from disturbance.

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone includes providing a more natural freshwater outflow pattern from the Delta in dry and normal rainfall years, restoring tidal and nontidal wetlands, restoring tidal perennial aquatic habitat, and screening unscreened and poorly screened diversions. These changes will assist in the recovery of special-status species and increase important fish, wildlife, and plant communities. Local and regional agency and stakeholder initiatives will help attain this vision.

The vision focuses on improving the natural freshwater inflow pattern to San Francisco Bay and restoring important, tidally influenced aquatic and wetland habitats and adjacent uplands. Other focal points are reducing stressors, such as non-native marine invertebrates in ship ballast water and contaminants in municipal, industrial, and agricultural discharges into the Bay, and reducing losses of juvenile fish and their food organisms at unscreened diversions. Habitat improvements will benefit the salt marsh harvest mouse, Suisun song sparrow, California clapper rail, and California black rail, as well as many native waterfowl and wildlife species living in and around the North

Bay. Improving freshwater inflow and habitat will benefit delta smelt, splittail, chinook salmon, striped bass, longfin smelt, and other anadromous and resident marine and estuarine fishes and larger marine invertebrates (e.g., shrimp, crabs, and clams) of the Bay, as well as the estuarine foodweb (e.g., algae and planktonic and bottom-dwelling animals) on which the fish depend. Separate visions have been prepared for many of these processes, stressors, habitats, and species. Volume I contains additional detail on the status and restoration needs of these resource elements and the specific restoration approach.

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone is closely tied to the vision for the Sacramento-San Joaquin Delta Ecological Management Zone. It is indirectly related to visions for the mainstem rivers and tributary watersheds. Flows and habitats in these areas are integrally linked. Many important anadromous fish and waterfowl species that use the Central Valley are affected by conditions in multiple Ecological Management Zones.

Restoring Suisun Marsh and North San Francisco Bay will improve the natural production of marine, estuarine, and anadromous fish; resident wildlife; migratory waterfowl; other winter migrants and neotropical birds; and special-status plants, plant communities, and associated terrestrial invertebrates. Several waterfowl species whose populations have declined in recent times, such as the canvasback and redhead, should also benefit.

Improving Suisun Marsh and North San Francisco Bay health will help to achieve the restoration goals set for the Sacramento-San Joaquin Delta Ecological Management Zone. Likewise, improving conditions in the Sacramento-San Joaquin River Delta (Delta) will benefit the Bay.

Goals for the Suisun Marsh/North San Francisco Bay Ecological Management Zone include protecting and enlarging remaining areas of native habitat and establishing connectivity among these areas. Enlarging the San Francisco Bay and San Pablo Bay National Wildlife Refuges and other State and local wildlife areas; expanding restoration efforts in the Napa Marsh area, Petaluma Marsh, and Sonoma baylands; and restoring connectivity among these features will help achieve the vision for this Ecological Management Zone. Expanding restoration efforts in the northeastern portion of Suisun Marsh and restoring connectivity with areas such as the Jepson Prairie Preserve in the Yolo Basin Ecological Management Zone and the Sacramento-San Joaquin Delta Ecological Management Zone will also contribute to this effort.

Potentially high-quality spawning, rearing, and migrating habitat will be restored to benefit important fish species that use Suisun Marsh and the Bay during at least a portion of their lives. This effort includes improving freshwater inflow patterns, particularly in dry and normal water years, and restoring extensive areas of tidal aquatic and wetland habitats in Suisun Marsh and the Bay.

## VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

### SUISUN BAY AND MARSH ECOLOGICAL MANAGEMENT UNIT

The vision for the Suisun Bay and Marsh Ecological Management Unit is to restore tidal marsh and to restore and enhance managed marsh, riparian forest, grassland, and other habitats.

Efforts and opportunities to restore tidal action to selected managed wetlands and promote natural riparian and wetland succession in Suisun Marsh will be expanded. Shallow-water, wetland, and riparian habitats within the marsh and along the shorelines of the Bay will be protected and improved, where possible. Upland habitats adjacent to riparian and wetland habitats will also be protected and improved. Efforts will focus on increasing the acreage open to tidal flows (e.g., by removing or opening levees) and providing connectivity among habitat areas to aid in the recovery of species, such as the salt marsh harvest mouse, clapper rail, and black rail. Those habitat areas will provide essential shelter and nesting cover during high tides. Improving marsh and slough habitats will benefit chinook salmon, striped bass, delta smelt, splittail, and other estuarine resident fish in the marsh and Suisun Bay.

Diverting water from Suisun Marsh channels for managed nontidal wetlands and controlling the salinity of water entering the marsh through Montezuma Slough will continue, but with consideration for maintaining the natural hydrologic regime and salinity levels of the slough and marsh. Efforts to screen diversions in the marsh will also continue to minimize the entrainment of juvenile fish. Water quality standards specified in the 1995 Water Quality Control Plan will be met in the eastern marsh and at several locations in the central marsh. Flows into the northwestern marsh will be improved.

Water diversions from Suisun Bay for cooling at the Pittsburg power plant will be conducted with minimal adverse effects on eggs, larvae, and juvenile fish. New fish screening technology or alternative sources of cooling water (such as cooling towers) will be considered.

Oil refinery operations in the Bay will be modified to reduce discharges of high levels of contaminants, such as selenium.

Suisun Marsh and Suisun Bay will function as high-quality spawning and rearing habitat and an effective fish migration corridor. A healthy Suisun Marsh-Bay ecosystem will be an important link in the estuary foodweb by improving primary and secondary productivity. Marsh and Bay productivity will improve as freshwater inflow events increase in dry and normal years and acreage of tidal wetlands and associated tidal perennial aquatic habitat increases.

## Napa River Ecological Management Unit

The vision for the Napa River Ecological Management Unit is to restore large areas of tidal marsh to benefit salt marsh harvest mouse and California clapper rail, manage inactive salt ponds to benefit waterfowl; restore a continuous band of tidal marsh along the bayshore to benefit fish species; improve tidal circulation; manage diked wetlands and seasonal wetlands to improve seasonal ponding for shorebirds, wading birds and waterfowl; enhance riparian vegetation and marsh/upland transitional habitats; and provide upland buffers.

Restoration efforts will be focused in the Napa Marsh Wildlife Area, Cullinan Ranch, and Scagg Island. Habitats should be protected and natural expansion and succession should be supported to restore large, contiguous (connected) areas of tidal saline emergent wetland, riparian, and upland habitats. The existing habitat areas are sparse and low quality, because dikes and levees have disrupted the natural tidal flows and sediment supply that are essential to maintain marsh habitat. Restoring tidal action to additional portions of the marsh and improving water quality will enhance the health of the marsh. This, in turn, will aid in the recovery of species, such as the salt marsh harvest mouse and clapper rail in the southern part of the Ecological Management Unit. Fish species, such as chinook salmon, striped bass, splittail, and delta smelt, will benefit from the improved health of the marsh and associated improvements in the tidal slough complex and lower river estuary.

## Sonoma Creek Ecological Management Unit

The vision for the Sonoma Creek Ecological Management Unit is to restore large patches of tidal marsh along the entire shoreline of San Pablo Bay; restore tidal marsh along Sonoma Creek;

establish managed mars or enhanced seasonal pond habitat for shorebirds; enhance riparian habitat along Sonoma Creek; and enhance marsh/upland transitional habitats.

Existing habitat will be maintained, and current and future restoration efforts in Napa/Sonoma Marsh will be expanded. The marsh is sparse and low quality, because dikes and levees have disrupted the natural sediment supply essential for maintaining marsh habitat. Leveed, historic marshland will be opened to tidal action, creating larger, more contiguous marsh areas. An expanded marsh/slough complex will support greater salt marsh harvest mouse and clapper rail populations, as well as splittail, delta smelt, juvenile chinook salmon, and striped bass. Restoration of existing managed marshlands may not be desirable as these lands support significant numbers of shorebirds and waterfowl. To achieve the restoration objective, acquisition and restoration of other diked baylands may be required.

### Petaluma River Ecological Management Unit

The vision for the Petaluma River Ecological Management Unit is to restore a continuous band of tidal marsh along the bayshore from Tolay Creek to the Petaluma River; restore tidal marsh along the Petaluma River; establish managed marsh or enhanced seasonal pond habitat on agricultural baylands not restored to tidal habitat; protect moist grasslands, and provide natural transitional habitat between marshes and upland areas.

Petaluma Marsh and its associated tidal slough network will be expanded. Outside of Petaluma Marsh, marsh habitat areas are sparse and low quality, because dikes and levees have disrupted the natural tidal flow and sediment supply essential for maintaining tidal emergent wetland habitat.

### San Pablo Bay Ecological Management Unit

The vision for the San Pablo Bay Ecological Management Unit is to restore tidal marsh along the bayshore and to establish managed marshes or enhance seasonal pond habitat on agricultural baylands not restored to tidal action.

The ecological health of San Pablo Bay and its function as an important nursery area for marine, estuarine, and anadromous fish can be improved by increasing freshwater inflow in spring during years with low and normal freshwater outflow, protecting and expanding tidal marsh/slough habitat complexes along the margins of the bay, and reducing the input of pollutants into the bay. Removing dikes and levees along the bay's shoreline, where appropriate, will aid in the recovery and expansion of tidal emergent wetland habitat.

## Visions for Ecological Processes

**Central Valley Streamflows:** A healthy pattern of freshwater inflow to Suisun Marsh and the North Bay would involve natural late-winter and spring flow events that support ecological processes and functions essential to the health of important Bay-Delta fish populations. Inflow to the Bay is impaired in dry and normal water years by storage and diversion of natural inflow to basin watersheds. The need for inflow to the Bay coincides with the need for natural flows in the mainstem rivers, their tributaries, and the Delta.

**Natural Floodplain and Flood Processes:** Expansion of the North Bay floodplain by setting back or removing levees would enhance floodwater and sediment retention and provide direct and indirect benefits to fish and wildlife that depend on natural floodplain inundation. Such floodplain expansion should also help to alleviate the flooding potential in other areas of the Bay-Delta.

**BAY-DELTA AQUATIC FOODWEB:** The aquatic foodweb of the Delta, which supports important resident and anadromous fish, has been severely impaired by drought, reductions in freshwater flow, water diversions, introductions of non-native species (e.g., Asiatic clams), and loss of shallow water and wetland habitats. Proposed improvements in spring flows, channel hydraulics, wetland habitats, and floodplain inundation should lead to a healthier and more productive aquatic foodweb. Improved water quality and greater sediment retention in wetland, riparian, and floodplain habitats will also increase foodweb productivity.

## VISIONS FOR HABITATS

**TIDAL PERENNIAL AQUATIC HABITAT:** Aquatic habitat within and associated with tidal wetland habitat is important to fish populations that use the Bay. The area of such habitat has been substantially reduced over the past century by land reclamation. Large areas of tidal habitat have been diked and reclaimed for agriculture, salt production, industry, nontidal wetlands (e.g., duck clubs), and other uses. Restoring large areas of presently leveed land to tidal influence may increase important fish species production by providing more spawning, feeding, and migrating habitat and increasing foodweb production throughout the Bay.

**NONTIDAL PERENNIAL AQUATIC HABITAT:** Open water habitats in managed wetlands, such as ponds, provide valuable waterfowl and wildlife habitats. Such habitat should be included in restoration efforts involving nontidal saline emergent wetlands.

**TIDAL SLOUGHS:** Sloughs are an important native habitat for fish and wildlife. Many slough complexes in the wetlands along the North Bay have disappeared as a result of land reclamation and levee construction. Restoring tidal wetland-slough complexes will provide valuable habitat for fish, including chinook salmon, striped bass, delta smelt, and longfin smelt.

**SALINE EMERGENT WETLANDS (TIDAL):** Tidal saline emergent wetland habitat in the Bay has been drastically reduced as a result of land reclamation. Such habitat is essential to estuary functions and the health of many fish, waterfowl, and wildlife species. Wetlands also enhance water quality in the Bay by filtering out sediments and contaminants.

**SEASONAL WETLANDS:** Seasonal wetlands in Suisun Marsh provide valuable wetland habitat for waterfowl and shorebirds, as well as other wildlife.

**VERNAL POOLS:** Vernal pools provide habitat for many listed plant and invertebrate species. Vernal pool protection and restoration will be closely linked to other actions related to restoring wetland, riparian, and adjacent upland habitats.

**RIPARIAN AND SHADED RIVERINE AQUATIC HABITAT:** Riparian and shaded riverine aquatic (SRA) habitats have been greatly reduced as a result of development along streams in areas above the lower marshes, sloughs, and Bay shorelines. Such habitat has value to many special-status plant and animal species. In addition, SRA habitat is important for juvenile chinook salmon and many other resident and anadromous fish using the Bay.

**ESSENTIAL FISH HABITAT:** The Suisun Marsh/North San Francisco Bay Ecological Management Zone has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in this ecological management zone include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

**PERENNIAL GRASSLANDS:** Grasslands associated with wetland margins are important habitats for some special-status plant and wildlife species. Wetlands should be restored along with the associated aquatic and upland habitats.

## Visions for Reducing or Eliminating Stressors

**Water Diversion:** Water diversions in North Bay watersheds, in Suisun Marsh, and upstream in the Delta and rivers affect freshwater flow in the Bay and remove fish and their foodweb organisms from the Bay. Unscreened diversions will be screened and poorly functioning screens will be improved to reduce fish loss. Where possible, diversions will be consolidated to reduce the number of diversions requiring screening. Most diversions in the Bay are confined to Suisun Marsh and Suisun Bay.

**Invasive Species:** Over the past several decades, the inadvertent introduction of many marine and estuarine organisms from the Far East in the ballast water of ships has greatly changed the plankton and benthic invertebrate fauna of the Bay, with further consequences throughout the foodweb. Further changes can be expected if ballast water releases into the Bay are not restricted. Therefore, more stringent ballast water release restrictions are needed to reduce the influx of exotic species. Other invasive species such as exotic cordgrass (Spartina spp) are becoming established and control measures are needed to reduce future potential adverse affects.

**Non-Native Wildlife:** Reducing the numbers of non-native species and therefore the effects these species have on native wildlife will require a coordinated approach that includes restoring ecosystem processes and functions where applicable and possible, restoring native habitats, reducing or eliminating other stressors that suppress native species, and efforts to control non-native species.

**Predation and Competition:** Millions of chinook salmon and striped bass have been stocked in North Bay waters to improve the survival of these species and their contributions to spawning populations. Although the presence of these fish in the Bay could be considered natural, the stocking of millions of hatchery smolts into small areas of the North Bay within a short period may affect the survival and production of important Bay species, such as longfin smelt.

**Contaminants:** Toxic contaminants continue to enter the Bay in large amounts as a result of municipal, industrial, and agricultural discharges. These toxins have had a demonstrated adverse effect on the health, survival, and reproduction of many important Bay fish species and their foodweb organisms. Toxins in fish tissues also pose a health risk to people who eat fish from the Bay. Continuing to reduce levels of toxic contaminants from discharges and releases of toxins from sediment (i.e., disturbed by natural forces and dredging) is an essential step in the restoration program. The level of toxins in the Bay is also closely tied to inputs upstream in the Delta and rivers; therefore, efforts to improve water quality should be coordinated throughout the basin.

**Harvest of Fish and Wildlife:** Legal and illegal fish harvest may limit recovery of some populations in the Bay-Delta system and its watersheds. Striped bass, salmon, steelhead, and sturgeon harvest in the Bay may affect the recovery of these populations.

**Disturbance:** Human activity, particularly boat wakes in sloughs and channels in tidal wetland areas, disturbs nesting waterfowl and erodes habitat. Disturbance to the endangered California clapper rail which also may occur includes boating and hunting. Restricting boat speeds and access by motorized boats in special areas will reduce these stresses.

## Visions for Species

**Delta Smelt:** The vision for delta smelt is to recover this State-and federally listed threatened species in order to contribute to the overall species richness and diversity of the Bay-Delta. Recovery of the delta smelt population in the Bay-Delta will occur through improved freshwater inflow and Delta outflow patterns, greater foodweb productivity, increased areas and quality of aquatic habitats, and reduced effects of water diversions. Higher delta smelt production should be apparent in dry and normal water year types in response to improved flows, habitats, and foodweb, and reductions in stressors.

**LONGFIN SMELT:** The vision for longfin smelt is to recover this California species of special concern in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb. Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt.

**SPLITTAIL:** The vision for splittail is to recover of this federally listed threatened species. Recovery of the Bay-Delta splittail population will occur through improved floodplain inundation, higher late-winter Delta inflow, and improved tidal aquatic and wetland habitats. Greater production of young would be expected in dry and normal water year types.

**CHINOOK SALMON:** The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under the State or federal ESAs, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. Central Valley salmon populations will remain stable or increase with improved late-winter and spring flows into and through the Delta, increases in wetland and floodplain habitats, lower spring water temperatures, an improved aquatic foodweb, and reduced effects of water diversions. Survival rates through the Bay-Delta should increase. Numbers of young salmon rearing in the Bay-Delta should increase with improved winter-spring flows and wetland habitats.

**STEELHEAD TROUT:** The vision for Central Valley steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and the use fully existing and restored habitats. Steelhead will benefit from improved streamflows and riparian and shaded riverine aquatic habitat in the upper stream reaches. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

**STRIPED BASS:** The vision for striped bass is to maintain healthy populations, consistent with restoring native species, to their 1960s level of abundance to support a sport fisher in the Bay, Delta, and tributary rivers. The striped bass population will benefit from increased freshwater inflow to the Bay-Delta in late winter and spring, an improved aquatic foodweb, and reduced effects of water diversions. Improvements in water quality and reducing summer losses to diversions may be important in the long-term recovery of striped bass. Given the high reproductive capacity of striped bass, improvements in young production rates should be readily apparent when improvements are made to flow and foodweb, and when stressors are reduced.

**GREEN STURGEON:** The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historical levels. Sturgeon populations should remain stable or increase with improved streamflows and aquatic foodwebs.

**WHITE STURGEON:** The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Sturgeon populations should remain stable or increase with improved streamflows and aquatic foodwebs.

**American Shad:** The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Central Valley American shad populations will benefit from improved spring freshwater inflow to the Bay-Delta and an improved Bay-Delta aquatic foodweb. Populations would be expected to remain stable or increase. Increases would be expected in dry and normal rainfall years.

**Native Resident Fish Species:** The vision for native resident fish species is to maintain and restore the distribution and abundance of native species to contribute to overall species richness and diversity. Many native and non-native fish species will benefit from improved aquatic habitats and foodweb. Population abundance rates remain stable or increase. The distribution of native resident fishes should increase with widespread habitat restoration. The locally extinct Sacramento perch could be restored to new habitats in Suisun Marsh.

**Pacific Herring:** The vision for Pacific herring is to maintain self-sustaining populations in order to support commercial fishing. With improved freshwater inflow to the North Bay and Suisun Marsh and more tidal emergent wetland and associated tidal perennial aquatic habitat, marine and estuarine fish and invertebrate population abundance and distribution would increase. Pacific herring survival and production in the North Bay should increase with an improved aquatic foodweb.

**Bay-Delta Foodweb Organisms:** The vision for the Bay-Delta aquatic foodweb organisms is to restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities. Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and reducing loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Other elements include reducing losses to exports from the system and reducing the amount of toxic substances entering the system. Probably the best way to improve the aquatic foodweb is to restore tidal marshes and the connectivity to tidal flows in addition to the restoration of freshwater flows since and important part of the food web was probably driven by detritus originating from nearby marshes. A key to achieving this vision is expanded support of basic research to define and better understand the important links between the aquatic foodweb and adjacent terrestrial or transitional wetland foodweb.

**Grass Shrimp:** The vision for grass shrimp is to maintain self-sustaining populations in order to support recreational and commercial fisheries.

**Special Status Plant Species:** The vision for special status plant species is to contribute to their recovery by protecting and preserving important habitats sites within the Bay-Delta.

**California Freshwater Shrimp:** The vision for California freshwater shrimp is to maintain existing population distribution and abundance of the this federally listed endangered species.

**Giant Garter Snake:** The vision for giant garter snake is to contribute to the recovery of this State and federally listed threatened species. Restoring aquatic, riparian, and wetland habitats in the Bay-Delta will aid giant garter snake and western pond turtle recovery.

**Western Pond Turtle:** The vision for western pond turtle is to maintain and restore their abundance and distribution in order to contribute to overall species richness and diversity. Restoring aquatic, riparian, and wetland habitats in the Bay-Delta will aid giant garter snake and western pond turtle recovery.

**SWAINSON'S HAWK:** The vision for Swainson's hawk it to contribute to the recovery of this State and federally listed threatened species. Improvements in riparian and agricultural wildlife habitats will aid in the Swainson's hawk recovery. Increased sightings and possibly increased nesting would be expected in the Bay-Delta.

**CALIFORNIA CLAPPER RAIL:** The vision for California clapper rail is to contribute to the recovery of this State and federally listed threatened species. Restoring emergent wetlands in the North Bay and adjoining marshes should aid California clapper rail recovery. Population abundance and distribution should increase in the North Bay and adjoining marshes.

**CALIFORNIA BLACK RAIL:** The vision for California black rail is to contribute to the recovery of this State-listed threatened species. Restoring emergent wetlands in the North Bay and adjoining marshes should aid in California black rail recovery. Population abundance and distribution should increase in the North Bay and adjoining marshes.

**SUISUN SONG SPARROW:** The vision for the Suisun song sparrow is to recover this species of special concern in Suisun Marsh and the western Delta. The Suisun song sparrow abundance and distribution in the Suisun Marsh should increase with new tidal wetlands and improved riparian habitat in the marshes.

**ALAMEDA SONG SPARROW:** The vision for the Alameda song sparrow is to maintain and restore the habitat of this species of special concern. The Alameda song sparrow abundance and distribution should increase with new tidal wetlands and improved riparian habitat in the marshes.

**SALT MARSH HARVEST MOUSE:** The vision for the salt marsh harvest mouse is to contribute to the recovery of this State and federally listed endangered species through restoring salt marsh habitat in San Pablo and Suisun bays and adjacent marshes. New and improved salt marsh habitat in the North Bay and adjoining marshes will help in salt marsh harvest mouse recovery.

**SAN PABLO CALIFORNIA VOLE:** The vision for the San Pablo California vole is to contribute to the recovery of the species of special concern to contribute to overall species richness and diversity.

**SUISUN ORNATE SHREW:** The vision for the Suisun ornate shrew is to recover this California species of special concern to contribute to overall species richness and diversity.

**SHOREBIRDS AND WADING BIRDS:** The vision for the shorebird and wading bird guilds is to maintain and restore healthy populations through habitat protection and restoration, and reduction is stressors. Shorebirds and wading birds will benefit from wetland, riparian, aquatic, and agricultural habitats restoration. Seasonal use of the North Bay and adjoining marshes by these birds should increase.

**WATERFOWL:** The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and North American Waterfowl Management Plan. Many resident and migratory waterfowl species will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the North Bay and adjoining marshes and, possibly, increases in some populations would be expected.

**DELTA GREEN GROUND BEETLE**: The vision for the Delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing their populations and abundance through habitat restoration.

## INTEGRATION WITH OTHER RESTORATION PROGRAMS

Changing freshwater inflow patterns to the Bay, the major ecosystem process in the plan for the Delta, is a longstanding need; however, without developed supplies, the prescribed spring flow events and minimum freshwater inflows may not be available in all water-year types. In the short term, efforts will focus on providing the needed flows with available water supplies from the Central Valley Project (CVP) facilities at Shasta, Folsom, and New Melones Reservoirs using water prescribed by the Central Valley Project Improvement Act (CVPIA) and water purchased from willing sellers. The effectiveness of the water releases would be maximized through the use of tools such as water transfers. Property acquisitions with water rights from willing sellers are also a tool for acquiring water. In the long term, additional water supplies may be needed to meet remaining environmental needs.

Much of the infrastructure to implement the vision for the marsh and bay already exists. Restoration will be implemented through these existing programs. In areas where no cooperative agency and stakeholder efforts are underway, such organizations can be developed to help implement the program. To be successful, the restoration program must help to coordinate existing restoration programs being undertaken by State and federal resource agencies.

The recommendations in this plan will coincide with numerous programs and projects to protect and restore the Bay-Delta estuary. These programs are described below.

### SAN FRANCISCO BAY AREA WETLANDS ECOSYSTEM GOALS PROJECT

The San Francisco Bay Area Wetlands Ecosystem Goals Project is a comprehensive, science-based program which had developed recommendations regarding where and how much of the various types of wetland should be restored in the Suisun Bay and San Francisco Bay areas. Many of the goals that have been presented are consistent or enhance the ERPP prescriptions to improve the ecological health of processes, habitats, and species in this ecological management zone.

### SAN FRANCISCO ESTUARY PROJECT

The San Francisco Estuary Project has four goals to restore the physical, chemical, and biological integrity of the San Francisco Bay-Delta Estuary:

- protect existing wetlands,
- restore and enhance the ecological productivity and habitat values of wetlands,
- expedite a significant increase in the quantity and quality of wetlands, and
- educate the public about the values of wetland resources.

### CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the Suisun Marsh and North Bay Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. With the CVPIA program, the Anadromous Fish Restoration Program (AFRP) of the U.S. Fish and Wildlife Service (USFWS 1997) has a goal to double the natural anadromous fish production in the system over the average production during 1967 through 1991. CVPIA authorized dedicating and managing 800,000 af of CVP yield annually to implement the fish, wildlife, and habitat restoration purposes and measures that include water purchased for inflow to and outflow from the Delta. The CVPIA AFRP includes provisions for restoring habitat and reducing stressors, such as unscreened water diversions.

## Recovery Plan for Sacramento-San Joaquin Delta Native Fishes

The scope of the plan includes San Francisco Bay and the Delta. The intent is to promote conservation of the ecosystems on which the native fishes, such as chinook salmon, delta smelt, longfin smelt, splittail, and Sacramento perch, depend. The plan outlines a strategy for restoration, including actions, The goals, strategies for recovery, and programmatic actions presented in the plan have been adopted by the ERPP. The plan includes targets for populations, habitat restoration, structural changes, and Delta outflow to the Bay that have been included in the ERPP. Important recovery actions in this plan include placing the 2 parts per thousand isohaline (X2 SWRCB standard) at Roe Island, Chipps Island, or at the confluence of the Sacramento-San Joaquin rivers at Collinsville. Suitable placement of the 2 parts per thousand isohaline is key to providing adequate shallow water habitat for delta smelt, longfin smelt, and splittail.

## Recovery Plan for Salt Marsh Harvest Mouse and California Clapper Rail

The recovery plan for the salt marsh harvest mouse and clapper rail focuses on protecting existing marshes, creating new marsh habitat with unrestricted tidal sloughs, pickleweed habitat for mice, and suitable nesting habitat for the rail. This recovery plan, prepared and approved in 1984, is being revised by the USFWS. The goals and objectives that are being developed in the revised recovery plan may lead to corresponding adjustments in ERPP targets and programmatic actions.

## Suisun Marsh Management and Protection Plans

The Suisun Marsh Management Plan was mandated by the Suisun Marsh Preservation Act of 1977. Its goal is to maximize waterfowl food production while maintaining a diverse marsh flora capable of supporting the present wide variety of wildlife in the marsh. The plans were developed to mitigate (avoid, reduce, or compensate for) the effects on the marsh of the federal Central Valley Project and State Water Project. Though the plan's focus is to manage diked wetlands, plan elements are consistent with ERPP objectives and targets. A primary management area, consisting of 58,000 acres of tidal and managed wetlands, and secondary management areas of 28,000 acres of grasslands, have been identified for management and protection. Restoring tidal wetlands and sloughs in Suisun Marsh will be consistent with Suisun Marsh Management Plan goals.

## Interagency Ecological Program Suisun Ecological Workgroup

The Suisun Ecological Workgroup (SEW) was convened at the request of the State Water Resources Control Board as a component of the "Program of Implementation" in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. SEW is and ad hoc multi-agency/organization work group whose goal is to review the scientific basis for the current salinity standards in Suisun Marsh and make recommendations for comprehensive brackish marsh standards. The primary goals of the SEW are: (1) characterize the brackish water ecosystem for Suisun Marsh, (2) evaluate the effects of existing Western Suisun Marsh water quality standards on beneficial uses, (3) determine and recommend appropriate resource-specific standards; (4) recommend narrative standards for tidal wetlands, (5) assess impacts of implementing appropriate resources-specific standards on other resources, (6) develop appropriate multi-resource (ecosystem) water quality standards, (7) consider alternative models, and (8) recommend future studies and compliance monitoring programs.

## Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture is a component of the USFWS's North American Waterfowl Management Plan, with funding and cooperative project participation by federal, State, and private agencies. New funding sources including CALFED restoration funds, are being sought to implement the Joint Venture. The Joint Venture has adopted an implementation plan that includes Suisun Marsh. Objectives include protecting wetlands by acquiring fee-title or conservation easements and enhancing waterfowl habitat in wetlands and agricultural lands. Joint Venture objectives and targets have been adopted by the ERPP.

## Recovery Plan for the Sacramento River Winter-Run Chinook Salmon

The winter-run recovery plan is being prepared and will be implemented by the Nation Marine Fisheries Service (NMFS). The draft plan includes recommendations for improving riparian and tidal marsh habitats in the Bay and Delta. ERPP objectives and targets are consistent with those of the recovery plan.

## San Francisco Estuary Project Comprehensive Conservation and Management Plan

The San Francisco Estuary project's (SFEP's) purpose is to promote effective management of the Bay-Delta estuary and restore and maintain the estuary's water quality and natural resources. There are eleven programs within the management plan, including wetland management and habitat restoration in the North Bay stream watersheds. Programs include protecting remnant stream habitats and restoring shaded riverine aquatic habitats. Objectives include restoring and creating habitats, including tidal saltmarsh and adjacent upland habitats. A plan is being developed for managing the San Francisco Bay National Wildlife Refuge. Many SFEP and CCMP objectives and targets are included in the ERPP.

## Agreement on San Joaquin River Protection

In an effort to resolve issues brought forth in the State Water Resources Control Board's 1995 Water Quality Control Plan for the Bay/Delta, the San Joaquin River Tributaries Association, San Joaquin River Exchange Contractors Water Authority, Friant Water Users Authority, and the San Francisco Public Utilities Commission collaborated to identify feasible, voluntary actions to protect the San Joaquin River's fish resources. In spring 1996, these parties agreed on a "Letter of Intent to Resolve San Joaquin River Issues." This agreement, when finalized, has the potential of providing the following:

- higher minimum base flows,
- significantly increased pulse flows,
- installation and operation of a new fish barrier on the mainstem San Joaquin River,
- set up a new biological monitoring program, and
- set aside federal restoration funds to cover costs associated with these measures.

One of the important components of the Agreement is the development of the Vernalis Adaptive Management Program (VAMP) to improve environmental conditions on the San Joaquin River. Elements of this potential adaptive management program include a range of flow and non-flow habitat improvement actions throughout the watershed, and an experimental program designed to collect data needed to develop scientifically sound fishery management options for the future.

### CALFED Bay-Delta Program

CALFED has funded seven ecosystem restoration projects in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Two projects screen diversions for managed wetlands on the Suisun Marsh and three restore habitat. A project by the Central Costa County Sanitary District discourages pesticide use by encouraging homeowners to use integrated pest management techniques.

## Linkage to Other Ecological Management Zones

Restoration efforts in all Ecological Management Zones upstream of the Suisun Marsh and North San Francisco Bay will contribute to the health and recovery of this zone. Likewise, efforts in this zone will contribute to the health of the Delta and salmon and steelhead population recovery in the Sacramento and San Joaquin River basins.

Successfully realizing the vision for this Ecological Management Zone depends, in part, on achieving targets in the Sacramento-San Joaquin Delta, Sacramento River, Eastside Delta Tributaries, and San Joaquin River Ecological Management Zones. These include targets associated with restoring streamflow processes, reducing contaminants, and improving and increasing riparian and wetland habitats. Efforts toward achieving targets in these zones should interact to restore important rearing habitat, reduce the introduction of contaminants, and control the introduction of non-native aquatic species. For example, essential for meeting the Bay freshwater inflow prescriptions are efforts to meet the individual flow prescriptions for the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers. Aquatic, riparian, and wetland corridors in the Delta are also directly linked and integral to habitat corridors in Suisun and San Pablo Bays.

## Restoration Targets and Programmatic Actions

### Ecological Processes

#### Central Valley Streamflow (Freshwater Inflow)

**Target 1:** More closely emulate the natural seasonal freshwater inflow pattern to North San Francisco Bay to:

- transport sediments,
- allow upstream and downstream fish passage,
- contribute to riparian vegetation succession,
- permit transport of larval fish to the entrapment zone,
- maintain the low salinity zone in Suisun Bay, and
- provide adequate attraction flows for upstream, through-Bay migrating salmon.

Delta outflow in dry and normal years will be improved by coordinating releases and natural flows in the Sacramento River Basin to provide a March flow event of at least 20,000 cfs for 10 days in dry years, at least 30,000 cfs for 10 days in below-normal years, and at least 40,000 cfs for 10 days in above-normal years. The existing smaller, late-April and early-May flow event will be improved with additional water releases from San Joaquin River and Delta tributaries to provide flows of magnitudes and durations similar to those prescribed for March (◆◆).

**Programmatic Action 1a:** Develop a cooperative program to provide target flows in dry and normal years by allowing inflows to major storage reservoirs, prescribed in the visions of upstream Ecological Management Zones, to pass downstream into and through the Delta. (This action would result from an accumulation of recommendations for spring flow events and minimum flows from upstream Ecological Management Zones.)

***Rationale:*** *Restoring freshwater flows into Suisun Marsh/North San Francisco Bay Ecological Management Zone consistent with natural hydrologic conditions in the Bay-Delta watershed will help restore fundamental ecosystem processes and functions for the North Bay's aquatic and wetland resources. Increasing spring freshwater inflows will benefit the Bay and help move outmigrating juvenile chinook salmon and steelhead through the Bay toward the ocean. Spring plankton blooms in the North Bay, stimulated by freshwater outflow, support the North Bay's functions as a primary nursery ground for many important fish and crustacean species. These include chinook salmon, striped bass, delta smelt, splittail, Pacific herring, starry flounder, northern anchovy, Dungeness crab, several species of Bay shrimp, and many species of planktonic and benthic invertebrates that make up the Bay's foodweb. Spring freshwater flows also stimulate tidal emergent marsh productivity by providing necessary nutrients and sediments. Freshwater inflows of 20,000 to 40,000 cfs in dry and normal years, compared to the existing 10,000 to 30,000 cfs, would ensure that the low salinity zone of the estuary and X2 would be located well downstream in Suisun Bay, especially in dry years, and allow some fresh water to reach San Pablo Bay through tidal circulation and mixing. (Note: the location of X2 is the distance from the Golden Gate Bridge to the point at which the daily average salinity is 2 parts per thousand (ppt) at the bottom.)*

## Natural Floodplain and Flood Processes

**Target 1:** Expand the floodplain area in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units by putting approximately 10% of leveed lands into the active floodplain (◆◆◆).

**Programmatic Action 1a:** Convert leveed lands to tidal wetland/slough complexes.

***Rationale:*** *Restoring approximately 10% of existing leveed lands to tidal action and floodflows will greatly enhance the floodwater and sediment retention capacity of the area and contribute nutrients for the aquatic foodweb.*

## Bay-Delta Aquatic Foodweb

**Target 1:** Increase primary and secondary nutrient productivity in the Suisun Marsh/North San Francisco Bay to levels historically observed in the 1960s and early 1970s (◆◆).

**Programmatic Action 1a:** Actions described to restore streamflow, floodplains, tidal wetlands and sloughs, and riparian habitat would increase primary and secondary productivity in the Suisun and North San Francisco Bay areas.

**Programmatic Action 1b:** Implement an expanded aquatic foodweb research program to better understand the linkage of adjacent and transitional wetland habitats and the aquatic foodweb.

***Rationale:*** *Increasing the area of tidal wetland/slough habitat will increase primary and secondary productivity. More flooding of floodplains will provide more nutrients and organic carbon inputs.*

## HABITATS

### GENERAL RATIONALE

*Restoring tidally influenced wetlands are an essential focus of restoration efforts in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Habitats of particular interest include tidal perennial aquatic habitat, saline emergent wetlands, and tidal slough habitat. Restoration of these habitats will require a mosaic of habitats including adjacent habitats that need to be comprised of seasonal wetlands, non-tidal perennial aquatic habitats, perennial grasslands, and riparian habitats. Restoration targets were set with the realization of the difficulty in locating lands for restoration. In the Suisun Marsh, for example, the restoration of tidally influenced habitats will likely require the conversion of existing managed wetlands. The conversion of these existing freshwater wetlands will be offset to the extent possible by restoring existing degraded wetland habitats and by improvement to existing unmanaged wetlands. Likewise, in the San Pablo Bay Ecological Management Unit, restoration of habitat will be constrained by the fact that the area is characterized by open bay and intertidal flats with very limited opportunities for restoration of other shallow water habitat types.*

### TIDAL PERENNIAL AQUATIC HABITAT

**TARGET 1:** Restore 1,500 acres of shallow-water habitat in the Suisun Marsh/North San Francisco Bay Ecological Management Zone (◆◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to acquire and restore 1,500 acres of shallow-water habitat in the Suisun Bay and Marsh Ecological Management Unit.

**PROGRAMMATIC ACTION 1B:** Develop a cooperative program to evaluate the feasibility of restoring shallow-water habitat in the San Pablo Bay Ecological Management Unit.

***RATIONALE:*** *Restoring, improving, and protecting high-quality, shallow-water habitat will provide foraging habitat for juvenile fish in this Ecological Management Zone. These areas typically provide high primary and secondary productivity and support nutrient-cycling functions that can sustain high-quality foraging conditions. Opening new areas to tidal flows will also help restore a more natural tidal action to the Bay-Delta. These tide-influenced areas also provide high-quality foraging habitat for waterfowl that use mudflat or submergent vegetation growing in shallow water and diving ducks, such as canvasback and scaup, that consume clams in these areas (Fris and DeHaven 1993, Brittain et al. 1993, Stuber 1984, Schlosser 1991, Sweetnam and Stevens 1993, San Francisco Estuary Project 1992a, U.S. Fish and Wildlife Service 1996, and Lindberg and Marzuola 1993).*

*Restoration of shallow water habitat in the San Pablo Bay Ecological Management Unit may not be possible as the unit is characterized by open bay and intertidal flats. No lands may be available for restoration.*

*Development of shallow water habitats in the North Bay will require large-scale tidal restoration to expand and maintain third through fifth order slough channels. Larger sloughs provided the shallow water habitat which existed under historic conditions in the North Bay. Acquiring and restoring diked subsided lands will create shallow water habitats in the short-term. Sedimentation will occur over the long-term and the area will develop into a saline emergent marsh. This objective is probably only achievable in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units.*

### NONTIDAL PERENNIAL AQUATIC HABITAT

**TARGET 1:** Develop 1,600 acres of deeper (3-6 feet deep) open-water areas to provide resting habitat for water birds, foraging habitat for diving ducks and other water birds that feed in deep water (◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to acquire and develop 400 acres of deeper open-water areas adjacent to restored saline emergent wetland habitats in the Suisun Bay and Ecological Management Unit.

**PROGRAMMATIC ACTION 1B:** Develop a cooperative program to acquire and develop 400 acres of deeper open-water areas adjacent to restored saline emergent wetland habitats in each the Napa River, Sonoma Creek and Petaluma River Ecological Management Units (1,200 acres total).

***RATIONALE:*** *Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife species will increase the overwinter survival rate of these populations. Other water-associated wildlife species will also benefit (Madrone Associates 1980).*

### TIDAL SLOUGHS

**TARGET 1:** Restore slough habitat for fish and associated wildlife species. Restore 5 miles of slough habitat in the near-term, and 10 miles in the long-term, in the Suisun Bay and Marsh Ecological Management Unit. Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Napa River Ecological Management Units. Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Sonoma Creek Ecological Management Units. Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Petaluma River Ecological Management Units (◆◆).

**PROGRAMMATIC ACTION 1A:** In association with wetland/marsh restoration efforts, construct sloughs in marsh/slough complexes by acquiring land and purchasing easements.

***RATIONALE:*** *Restoring, improving, and protecting slough habitat in the units of the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help sustain high-quality shallow-water habitat that provides spawning habitat for native fish and foraging habitat for rearing juvenile fish. Restoring sloughs, along with tidally influenced freshwater areas and saline emergent marsh, will provide spawning habitat for native fish and foraging habitat for rearing juvenile fish; contribute to high levels of primary and secondary productivity; and support nutrient-cycling functions that can sustain high-quality foraging conditions. These sloughs can also provide resting sites for waterfowl and habitat for the western pond turtle (Simenstad et al. 1992, Lindberg and Marzuola 1993, and Madrone Associates 1980). Tidal sloughs can also provide important loafing sites for waterfowl, particularly diving ducks in the North Bay. The miles of targeted sloughs represent a reasonable restoration level as indicated by maps available from the early 1900s and existing configurations in the Ecological Management Units.*

*In general, tidal slough restoration should be associated by tidal marsh restoration. Sloughs are a function of the marshes they traverse. The acreage of marsh and soils, sediments, hydrodynamics will limit the amount of tidal marsh that can be restored. These sloughs can also provide loafing sites for waterfowl, particularly diving ducks in the North Bay.*

### SALINE EMERGENT WETLANDS

**TARGET 1:** Restore tidal action to 5,000 to 7,000 acres in the Suisun Bay and Marsh Ecological Management Unit; 1,000 to 2,000 acres in the Napa River Ecological Management Unit; 500 to 1,000 acres each in the Sonoma Creek, Petaluma River, and San Pablo Bay Ecological Management Units (◆◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to acquire, in fee-title or through a conservation easement, the land needed for tidal restoration, and complete the needed steps to restore the wetlands to tidal action.

**TARGET 2:** Protect 6,200 acres of existing saline emergent wetlands in the Suisun Bay and Marsh Ecological Management Zone.

**PROGRAMMATIC ACTION 2A:** Develop a cooperative program to acquire, in fee-title or through a conservation easement, existing wetlands subject to tidal action.

**TARGET 3:** Restore full tidal action to muted marsh areas along the north shore of the Contra Costa shoreline.

**PROGRAMMATIC ACTION 3A:** Develop a cooperative program to evaluate, acquire, in fee-title or through a conservation easement, and restore existing muted wetlands to full tidal action.

***RATIONALE:*** *Restoring tidally influenced saline marsh in this Ecological Management Zone will contribute to increasing levels of primary and secondary productivity and support nutrient-cycling functions that can sustain high-quality foraging conditions (Lindberg and Marzuola 1993, Miller 1993, Simenstad et al. 1992). Increasing the area occupied by saline tidal marsh in each Ecological Management Unit will help support the proper aquatic habitat conditions for rearing and outmigrating juvenile chinook salmon, steelhead, and sturgeon and rearing delta smelt, striped bass, and splittail. Restoring high-quality saline marshes, both tidal and nontidal, will contribute to nutrient cycling, maintaining the foodweb, and supporting enhanced levels of primary and secondary production. Increasing the area occupied by nontidal saline marsh will contribute to subsidence control and island accretion (growth) efforts. Permanent saline marsh can help arrest and, in some cases, reverse subsidence where peat oxidation has lowered land elevations to more than 15 feet below sea level. Increasing the area occupied by saline marsh will contribute to an ecosystem that can accommodate sea-level rise and provide a more natural tidal pattern and associated benefits to the foodweb and water quality of the Bay and Delta. Habitat conditions for wetland-associated wildlife will be improved.*

*The targets for saline emergent wetlands will probably be achieved or even exceeded by several ongoing programs. These include activities to restore saline emergent wetlands which are contained within land acquisition programs by the U.S. Fish and Wildlife Service and Department of Fish and Game.*

## SEASONAL WETLANDS

**TARGET 1:** Assist in protecting and enhancing 40,000 to 50,000 acres of existing degraded seasonal wetland habitat in the Suisun Bay and Marsh Ecological Management Unit per the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan. (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Support the cooperative program to improve management of up to 26,000 acres of degraded seasonal wetland habitat in the of the Suisun Bay and Marsh Ecological Management Unit.

**PROGRAMMATIC ACTION 1B:** Support the development of a cooperative program to improve management of up to 32,000 acres of existing seasonal wetland habitat in the Suisun Bay and Marsh Ecological Management Unit.

**TARGET 2:** Acquire and convert 1,000 to 1,5000 acres of existing farmed baylands in the Suisun Marsh to seasonal wetlands.

**PROGRAMMATIC ACTION 2A:** Develop a cooperative program to acquire, in fee-title or through a conservation easement, existing farmed baylands and restore tidal action.

***RATIONALE:*** *Restoring wetland and riparian habitats in association with aquatic habitats is an essential restoration strategy element for this*

*Ecological Management Zone. This restoration is fundamental to supporting the foodweb and enhancing conditions for rearing chinook salmon, steelhead, sturgeon, juvenile delta smelt, striped bass, and splittail. Foodweb support functions for wildlife will also benefit (Cummins 1974, Brostoff and Clark 1992).*

*Seasonal wetlands can help reduce concentrations and loads of pesticide residues in water and sediments, which help to reduce sublethal and long-term impacts of specific contaminants for which it is difficult to conclusively document population-level impacts. Modifying agricultural practices and land uses on a large scale will reduce the concentrations of pesticide residues through a combined approach. This approach involves reducing the amount of pesticide applied and the amount reaching aquatic Suisun Marsh and San Francisco Bay habitats. This will be done by biological and chemical processes in wetland systems that break down harmful pesticide residues. Improved inchannel flows in this Ecological Management Unit resulting from seasonal reductions in water use and enhanced environmental water supplies will also help to reduce contaminant concentrations (San Francisco Estuary Project 1992a).*

*Restoring high-quality freshwater marsh and brackish marsh, both seasonal and permanent, will increase the production and availability of natural forage for waterfowl and other wildlife. It will increase the overwinter survival rates of wildlife populations in this Ecological Management Zone and improve their body condition before they migrate. As a result, breeding success will be improved. Managing these habitats will also reduce the amount and concentrations of contaminants that could, upon entering the sloughs, interfere with efforts to restore aquatic ecosystem health.*

*Target 1 "enhance 40,000 to 50,000 acres of degraded seasonal wetland habitat" is consistent with the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan.*

*Programmatic Action 1A "enhance 26,000 acres of degraded seasonal wetland habitat" is already being implemented by Ducks Unlimited as part of a grant through the North American Wetlands Conservation fund. The intent of the ERPP is to remove the levees of some managed wetlands to allow the restoration of tidally influenced habitats and expand the acreages of wet meadows or pastures. The greatest need to restore where possible, tidal wetland areas. This may result in a need to replace any losses of managed wetlands by creating additional wetland areas. However, there may not be area for any additional acres of managed wetlands as the majority of agricultural lands have already been converted to managed wetlands. For example, the following figures provided by the Suisun Resource Conservation District display the possible difficulty in creating additional managed wetlands.*

| *Existing Land Use* | *Existing Acreage* |
|---|---|
| *managed wetlands* | *52,000 acres* |
| *unmanaged tidal wetlands* | *6,300 acres* |
| *bays and sloughs* | *30,000 acres* |
| *uplands and grasslands* | *27,700 acres* |

## VERNAL POOL

**TARGET 1:** Protect and manage vernal pools in the Suisun Bay and Marsh Ecological Management Unit that provide suitable habitat for listed fairy shrimp species, the Delta green ground beetle, and special-status plant species to assist in these species' recovery (◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to acquire and manage 100 acres of vernal pools and 500 to 1,000 acres of adjacent buffer areas

**TARGET 2:** Restore vernal pools that have been degraded by agricultural activities to provide suitable habitat for special-status invertebrates and plants and amphibian, such as the spadefoot toad, to assist in the recovery of these populations (◆).

**PROGRAMMATIC ACTION 2A:** Develop a cooperative program to restore the quality of vernal pools and their adjacent habitats.

***RATIONALE:*** *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential restoration strategy element for the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Restoring this habitat mosaic on a large scale will help restore ecosystem processes and functions and provide additional protection to listed species associated with this habitat type.*

## RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

**TARGET 1:** Restore 10 to 15 linear miles of riparian habitat along riparian scrub and shrub vegetation corridors in each Ecological Management Unit. In this restored habitat, 60% should be more than 15 yards wide, and 25% should be no less than 5 yards wide and 1 mile long (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Coordinate with landowners and managers to restore and maintain 10 to 15 linear miles of riparian habitat along corridors of riparian scrub and shrub vegetation in each Ecological Management Unit. Of this, 60% should be more than 15 yards wide, and 25% should be no less than 5 yards wide and 1 mile long.

***RATIONALE:*** *Many wildlife species, including several species listed as threatened or endangered under the State and federal Endangered Species Acts (ESAs) and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian scrub and shrub will help provide needed escape cover for these species during high-flow periods. Riparian vegetation in the western portion of the Suisun Marsh/North San Francisco Bay Ecological Management Zone is limited by water salinity. Riparian restoration will most likely occur in the upper reaches of the Ecological Management Units in areas that may be tidally influenced but which have low salinity.*

## ESSENTIAL FISH HABITAT

**TARGET 1:** Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

**PROGRAMMATIC ACTIONS:** No additional programmatic actions are recommended.

***RATIONALE:*** *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Delta ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of rivers and streams and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

## PERENNIAL GRASSLANDS

**TARGET 1:** Restore 1,000 acres of perennial grasses in each Ecological Management Unit associated with existing or proposed wetlands (◆◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to restore perennial grasslands by acquiring conservation easements or purchasing land from willing sellers.

***RATIONALE:*** *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential restoration strategy element for this Ecological Management Zone. Eliminating fragmentation and restoring connectivity will enhance habitat conditions for special-status species, such as the Suisun song*

**Table 5: Summary of ERPP Habitat Restoration Targets and Programmatic Actions for the Suisun Marsh/ North San Francisco Bay Ecological Management Zone.**

| Habitat Type | Suisun Bay and Marsh | Napa River | Sonoma Creek | Petaluma River | San Pablo Bay | Total |
|---|---|---|---|---|---|---|
| Tidal Perennial Aquatic | 1,500 | 0 | 0 | 0 | Feasibility study | 1,500 acres |
| Nontidal Perennial Aquatic (deep, open water) | 400 | 400 | 400 | 400 | 0 | 1,600 acres |
| Tidal Sloughs (short-term) | 5 miles | 10 miles | 10 miles | 10 miles | 0 | 35 miles |
| Tidal Sloughs (long-term) | Additional 5 miles | Additional 10 miles | Additional 10 miles | Additional 10 miles | 0 | 35 miles |
| Saline Emergent Wetland (restore) | 5,000-7,000 | 1,000-2,000 | 500-1,000 | 500-1,000 | 500-1,000 | 7,500 -12,000 acres |
| Saline Emergent Wetland (protect) | to be determined (TBD) | TBD | TBD | TBD | TBD | 6,200 acres |
| Seasonal Wetland (Protect existing) | 40,000-50,000 | 0 | 0 | 0 | 0 | 40,000-50,000 acres |
| Seasonal Wetland (Restore) | 1,000-1,500 | 0 | 0 | 0 | 0 | 1,000-1,500 acres |
| Vernal Pools | 100 | 0 | 0 | 0 | 0 | 100 acres |
| Vernal Pool Buffer Area | 500-1,000 | 0 | 0 | 0 | 0 | 500-1,000 acres |
| Riparian and Riverine Aquatic | 10-15 miles | 10-15 miles | 10-15 miles | 10-15 miles | 10-15 miles | 50-75 miles |
| Perennial Grassland | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 5,000 acres |
| Total acres of all habitats to be restored include tidal perennial, nontidal perennial saline emergent wetland, seasonal wetland, vernal pool and vernal pool buffer, and perennial grassland. | | | | | | 17,200-22,700 acres |
| Total acres of existing habitats to be protected and enhanced | | | | | | 46,200-56,200 acres |
| Total miles of tidal sloughs to be restored | | | | | | 70 miles |
| Total miles of riparian and riverine aquatic habitat to be restored | | | | | | 50-75 miles |

*sparrow, California black rail, and salt marsh harvest mouse. For instance, the habitats for these species have been degraded by the loss of adjacent, suitable escape cover that is needed by the salt marsh harvest mouse during periods of high flows or high tides. Fragmentation has also interfered with daily and seasonal migratory movements and genetic interchange within the population (Novick and Hein 1982).*

## REDUCING OR ELIMINATING STRESSORS

### WATER DIVERSIONS

**TARGET 1:** Reduce entrainment losses of juvenile fish at diversions by 25 to 50% by installing positive-barrier fish screens on large diversion structures (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to consolidate, screen, or eliminate diversions in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

***RATIONALE:*** *Large diversions on the main channels of Suisun and San Pablo Bays and adjoining marsh/slough complexes entrain juvenile and small adult fish at rates that could be detrimental to the survival of species of special concern (Chadwick and Von Geldern 1964, 1974; Larkin 1979; and Erkkila et al. 1950). The reduction target reflects preliminary data indicating that entrainment through the smallest diversions on small channels might not pose a significant threat to the successful restoration of Bay-Delta health. The success of screening in the estuarine zone is difficult and dependent on critical protective operations and facilities. For example, bypass flows or bypass systems are needed to move target species away from the zone of influence and into areas safe from entrainment.*

### INVASIVE AQUATIC PLANTS

**TARGET 1:** Manage existing and restored dead-end and open-end sloughs and channels within the Ecological Management Zone so that less than 1% of the surface area of these sloughs and channels is covered by invasive non-native aquatic plants (◆◆).

**PROGRAMMATIC ACTION 1A:** Conduct large-scale, annual weed eradication programs throughout existing and restored dead-end and open-end sloughs and channels in each Ecological Management Unit so that less than 1% of the surface area of these sloughs and channels is covered by invasive non-native aquatic plants within 10 years.

***RATIONALE:*** *Invasive aquatic plants have altered ecosystem processes, functions, and habitats by modifying the foodweb and competing for nutrients, light, and space. Nesting birds are particularly vulnerable to increased predation from non-native ground-dwelling predators and competition from non-native nest parasites. Actions taken in the Suisun Marsh/North San Francisco Bay Ecological Management Zone to address this objective are prescribed primarily to enhance foodweb functions and improve habitat conditions for resident, estuarine, and anadromous fish and neotropical migratory birds. This can be accomplished, in part, by reducing the area inhabited by invasive non-native plants and by restoring large areas of optimal nesting habitat (Dudley and D'Antonio 1994, Anderson 1990, Zedler 1992, and Bay-Delta Oversight Council 1994).*

### INVASIVE AQUATIC ORGANISMS

**TARGET 1:** Reduce or eliminate the influx of non-native aquatic species in ship ballast water (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Fund additional inspection staff to enforce existing regulations.

**PROGRAMMATIC ACTION 1B:** Help fund research on ballast water treatment techniques that could eliminate non-native species before ballast water is released.

**TARGET 2:** Reduce the potential for influx of non-native aquatic plant and animal species at border crossings (◆◆◆).

**PROGRAMMATIC ACTION 2A:** Provide funding to the California Department of Food and Agriculture to expand or establish, as appropriate, a comprehensive program to exclude, detect, and manage invasive aquatic species, such as zebra mussel.

**RATIONALE:** *Every reasonable effort should be made to reduce the introduction of non-native organisms in the ballast water of ships that enter the Delta. Such organisms have greatly altered the zooplankton of the Delta over the past several decades. Further alteration could reduce the capacity of the Delta to support native fishes.*

*Every reasonable effort should be made to reduce the introduction of non-native organisms at border crossings into California. Border inspections have already found zebra mussels, which, if allowed to enter Bay-Delta waters, could have devastating economic and ecological effects.*

## INVASIVE RIPARIAN AND MARSH PLANTS

**TARGET 1:** Reduce by 50% the area covered by invasive non-native woody species, such as giant reed and eucalyptus, that compete with native riparian vegetation, and eradicate invasive woody plants from restoration areas (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to remove and suppress invasive non-native plants that compete with native riparian vegetation by reducing the area occupied by these species (such as giant reed and eucalyptus) by 50%.

**PROGRAMMATIC ACTION 1B:** Develop a cooperative program to eliminate invasive woody plants from restoration sites to protect native riparian vegetation.

**PROGRAMMATIC ACTION 1C:** Develop a cooperative program to develop control measures for perennial pepperweed.

**RATIONALE:** *Invasive non-native plants have altered ecosystem processes, functions, and habitats by modifying the foodweb and competing for nutrients, light, and space (Dudley and D'Antonio 1994, Madrone Associates 1980, Bay-Delta Oversight Council 1994, Cross and Fleming 1989, and Zedler 1992).*

## NON-NATIVE WILDLIFE

**TARGET 1:** Reduce red fox and feral cat populations in and adjacent to habitat areas suitable for California clapper rail, California black rail, and salt marsh harvest mouse.

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to evaluate means to reduce red fox and feral cat populations through trapping, relocation, fertility control, or other suitable measures.

**PROGRAMMATIC ACTION 1B:** Develop and implement a public education program that emphasizes the ecological value of maintain coyote populations.

**RATIONALE:** *The large-scale restoration of emergent wetlands, riparian habitat, and adjacent perennial grasslands will be the main focus of a strategy to reduce the adverse impacts of non-native wildlife on the health of the Bay-Delta ecosystem. The goal is a restored Bay-Delta and watershed where the quality, quantity, and structure of the restored habitat discourage colonization by non-native wildlife, provide a competitive advantage to native wildlife, and reduce the vulnerability of native species from predation by species such as the red fox and feral* *cat. A public education program to inform duck club owners of the ecological importance of native coyotes in the Suisun region may help prevent the potentially devastating spread of red fox further into the Suisun Marsh and Delta region. Coyotes are native to the region and tend to keep foxes from increasing their range.*

*One of the most serious environmental problems facing California is the explosive invasion of non-native pest plants and animals. Non-native plants, wildlife, fish, and aquatic invertebrates can greatly alter the ecosystem processes, functions, habitats, species diversity, and abundance of native plants, fish, and wildlife.*

*Many of these invasive species spread rapidly and form dense populations primarily by out-competing native species as a result of large-scale habitat changes that tend to favor non-native species and a lack of natural controls (e.g., natural predators). These non-native species usually have a competitive advantage because of their location in hospitable environments where the normal controls of disease and natural enemies are missing. As populations of non-native species grow, they can disrupt the ecosystem and population dynamics of native species. In some cases, habitat changes have eliminated connectivity of habitats that harbor the native predators that could help to limit populations of harmful non-native species.*

## PREDATION AND COMPETITION

**TARGET 1:** Limit striped bass supplementation to life stages that minimize predation on juvenile anadromous and estuarine fish (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Provide sufficient equipment, support staff, and operation and maintenance funds to hold juvenile striped bass longer so they can be planted at 2 years of age instead of 1 year.

**PROGRAMMATIC ACTION 1B:** Cooperatively develop an ecologically based approach to limit striped bass and chinook salmon stocking in the Bay to areas and periods that will not increase predation on special-status species, such as longfin smelt and delta smelt, and other native fishes.

**RATIONALE:** *Actions taken in this Ecological Management Zone are prescribed to protect populations of aquatic species, such as longfin smelt and delta smelt, from excessive predation rates caused by large concentrations of stocked hatchery-reared fish. Limited studies have shown that two-year-old striped bass have less of an impact on anadromous and estuarine fish than one-year-old striped bass.*

## CONTAMINANTS

**TARGET 1:** Reduce the input of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife in the Suisun Marsh/North San Francisco Bay Ecological Management Zone (◆).

**PROGRAMMATIC ACTION 1A:** Support programs already in place to regulate the discharge of pollutants or reduce pollutant toxicity in Bay waters.

**RATIONALE:** *Reducing the concentrations and loads of contaminants, including hydrocarbons, heavy metals, and other pollutants, in the water and sediments of the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help reduce sublethal and long-term impacts of specific contaminants for which it is difficult to conclusively document population-level impacts. Reducing loading in urban runoff and modifying agricultural practices and land uses on a large scale will reduce pesticide residue concentrations through a combined approach. This approach involves reducing the amount of pesticide applied and the amount reaching the Bay's aquatic habitats. This will be done by biological and chemical processes in wetland systems that break down harmful pesticide residues. (Bay Delta Oversight Council 1994, Hall 1991, U.S. Fish and Wildlife Service 1996, San*

*Francisco Estuary Project 1992b, Resources Agency 1976, Sparks 1992, Diamond et al. 1993, and Rost et al. 1989).*

*Improved inchannel flows in the Delta resulting from seasonal reductions in water use and enhanced environmental water supplies will also help to reduce concentrations (San Francisco Estuary Project 1992a). Health warnings have been issued regarding human consumption of fish and wildlife because of elevated levels of substances, such as mercury and selenium. Large-scale aquatic and wetland habitats restoration may help to resolve concerns about hydrocarbons, heavy metals, and other pollutants. Addressing point sources of concern, such as the oil refineries in Suisun and San Francisco Bays, and elevated releases of selenium resulting from refining oil from sources high in selenium, can be effective elements of a strategy to achieve the desired reductions.*

## HARVEST OF FISH AND WILDLIFE

**TARGET 1:** Reduce illegal anadromous fish and waterfowl harvest in Suisun Marsh and San Francisco Bay by increasing enforcement and public education (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Provide additional funding to California Department of Fish and Game (DFG) for additional enforcement.

**PROGRAMMATIC ACTION 1B:** Provide additional funding to county sheriff's departments and State and local park agencies to support additional enforcement efforts.

**PROGRAMMATIC ACTION 1C:** Provide rewards for the arrest and conviction of poachers.

**PROGRAMMATIC ACTION 1D:** Develop and implement a public outreach/education program regarding the illegal harvest.

***RATIONALE:*** *Actions taken to reduce stressors in this Ecological Management Zone are prescribed primarily to contribute to the recovery of aquatic species, such as winter-, spring-, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. These actions will also contribute to the recovery of species, such as Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake (U.S. Fish and Wildlife Service 1996, San Francisco Estuary Project 1992b, Bay-Delta Oversight Council 1993, and California Department of Fish and Game 1991).*

## DISTURBANCE

**TARGET 1:** Reduce boat wakes near California clapper and black rail nesting areas in Suisun Marsh and San Francisco Bay from March to June to prevent destruction of nests and assist in the recovery of this listed species (◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program with local agencies to establish and enforce zones prohibiting boat wakes within 50 yards of California black rail nesting areas in Suisun Marsh and San Francisco Bay from March to June.

**PROGRAMMATIC ACTION 1B:** Develop a cooperative program with local agencies to establish and enforce zones prohibiting motorized boats in 5 miles of dead-end channels in Suisun Marsh and San Francisco Bay from March to June.

**PROGRAMMATIC ACTION 1C:** Develop a cooperative program with local agencies to establish and enforce zones prohibiting motorized boats in new, small channels in restored tidal fresh emergent wetlands.

***RATIONALE:*** *Clapper rail are particularly sensitive to disturbance and efforts to reduce jet ski traffic in critical areas for the rail would contribute to their recovery. Other actions taken to restore ecological processes and functions, increase and improve habitats, and reduce stressors in this Ecological Management Zone are* *prescribed primarily to contribute to the recovery of aquatic species, such as winter-, spring-, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. These actions will also contribute to the recovery of species, such as the black rail (Madrone Associates 1980, Schlosser 1991, San Francisco Estuary Project 1992a, U.S. Fish and Wildlife Service 1978, Schlorff 1991, and Resources Agency 1976).*

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